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THE

JOURNAL OF SCIENCE.

JANUARY, 1880.

I. THE HISTORY OF EVOLUTIONISM.*

EVOLUTIONISM, in the broad plain sense of the term, as opposed to the doctrine of mechanical-individual creation, may now be hailed as victorious along the whole line. In proof, we need only listen to the voices which are raising the well-known chorus:—"All this we knew long ago! Was there any need of a Darwin or a Wallace to tell us truths which are to be found embodied in classical myths, hinted at by early Christian fathers, and even shadowed forth in Holy Writ?" We might, indeed, ask the utterers of such voices how it comes that none of them was able to detect the great truth in these old sagas and writings till modern biologists found it in the Book of Nature? But it is not always good policy to tear away the veil under which neophytes hide the fact of their conversion.

Turning, then, from the initial controversy, we have to organise the territory which we have won. Accepting Evolution as God's way of Creation, we have before us the almost infinite task of tracing out how or by what agencies it is effected? why the organic world is as we find it, and not other? In connection with this undertaking we shall find it highly important to explore all the earlier suggestions and hypotheses which have been put forward as to Descent, its efficient causes, and its laws of operation. Not long ago we had the pleasure of reviewing a thoughtful and suggestive work,† in which the author seeks to prove that

* Erasmus Darwin. By ERNST KRAUSE. With a Preliminary Notice by CHARLES DARWIN. London: John Murray.

† Evolution, Old and New. By S. BUTLER.

Mr. C. Darwin,—and we presume Mr. Wallace,—instead of developing, have rather obscured the doctrines advanced by Erasmus Darwin, Buffon, and Lamarck. The volume now before us is therefore the more opportune. In it Dr. Krause gives a full, an able, and impartial survey of the genius and the researches of the elder Darwin, and assigns him a high place in the history of biological science.

It must not be imagined that prior to the appearance of the "Vestiges" the hypothesis of special creation had remained uncontroverted. Linnæus and Buffon were men of too philosophical intellects to accept as a matter of course the notion of a world mechanically made and peopled with plants and animals by a certain date, as if under contract. But their opinions wavered, perhaps according as evidence on the one or the other side suggested itself to their minds, —perhaps, also, as they were alternately swayed by private conviction or by prudential considerations. These fluctuations are most strikingly shown in the writings of Buffon. Mr. S. Butler solves the difficulty by interpreting all such passages favourable to the Old School as ironical—a somewhat hazardous expedient. But in the works of Erasmus Darwin—who, it must be remembered, is prior in point of time to Lamarck—we find no such wavering. He first established, as Dr. Krause insists, "a complete system of the theory of Evolution." At first sight, indeed, he might seem to have anticipated his illustrious grandson to a very serious extent. He discusses in his works the questions of heredity of adaptation, of the protective arrangements of animals and plants, and of sexual selection. He describes insectivorous plants. He analyses the emotions and social impulses, and seeks to trace out their origin. He suggests that all the limestone rocks in the world "were formed originally by animal and vegetable bodies from the mass of waters." He refers the Fungi to a third kingdom which, like a "narrow isthmus," unites plants and animals. He asks, "Do some genera of animals perish by the increasing power of their enemies? or do they still reside at the bottom of the sea? Or do some animals change their forms gradually, and become new genera?" It is only quite of late that we may venture to reply to the second of these questions in the negative. In tacit but yet unmistakable opposition to the shallow and mawkish teleology of his time, which viewed all nature in relation to man, and affected to know the hidden purposes of God, he asks—"Why has this plant poisonous juices? Why has that one spines? Why have birds and fishes light-coloured breasts and dark

backs?" He treats of the arrangements by which plants defend themselves from unbidden insect guests, thus, in part at least, anticipating a recent and most interesting work by Prof. Kerner. He points out that, in barren moorland districts, horses have learnt how to eat furze—a very nutritious plant—without wounding their mouths. He notices that flower-haunting birds and insects are gaily and vividly coloured, whilst larks, partridges, and hares resemble in their hues the dry vegetation or the earth upon which they rest. He observes that the snake and wild cat and leopard are so coloured as to imitate dark leaves and their lighter interstices. He pronounces the eggs of birds to be so coloured as to resemble adjacent objects. "The eggs of hedge-birds are greenish, with dark spots; those of crows and magpies, which are seen from below through wicker nests, are white, with dark spots; and those of larks and partridges are russet or brown, like their nests or situations." He suggests that, "like the fable of the chameleon, all animals may possess a tendency to be coloured somewhat like the colours they most frequently inspect, and, finally, that colours may thus be given to the egg-shell by the imagination of the female parent." These suppositions, as Dr. Krause reminds his readers, have lately been proved to be, in many cases, perfectly correct. He recognises the existence and the universality of the struggle for existence—a phenomenon overlooked to this day by a large portion of the intelligent and respectable classes, and sometimes denied even by compilers of books and writers of review-articles. How this contest rages in the apparently peaceful vegetable world Erasmus Darwin has well expressed in the following lines:—

> "Yes! smiling Flora drives her armed car
> Through the thick ranks of vegetable war;
> Herb, shrub, and tree with strong emotions rise
> For light and air, and battle in the skies;
> Whose roots diverging with opposing toil
> Contend below for moisture and for soil."

From such a recognition of the contest waged among all organisms it may seem no very wide step to the hypothesis of Natural Selection as *the* cause—according to the younger Darwin, or, we should rather submit, as *a* cause—of the variation of species. But it was never taken by Erasmus. He further expressed the idea which lies at the foundation of Mr. S. Butler's recent work, "Life and Habit," and which will doubtless effect the solution of all the remaining mysteries of instinct. He regarded the young animal as a

continuation, or, as he expresses it, as an "elongation of its parents," and as retaining in consequence the habits of the latter. He believed that the human race was at one time four-footed, and that hermaphroditism was the general condition even of the higher animals.

We might, indeed, fill much more space than stands at our disposal in showing to what an extent Erasmus Darwin anticipated the most recent biological researches and the most advanced speculations of our own day.

But we have now to meet the two main questions:—Why did he so completely fail to command the assent of the public? and wherein does his system differ from that of his illustrious grandson? That he did not carry conviction to the minds of even a minority of thinkers is undeniable. Even until quite recently the idea of a transformation of species, or of their origin in any other mode than that embodied in Milton's poetical gloss on the Mosaic cosmogony, was, in England at least, branded as philosophically false and theologically impious, and the very name of Darwin had become a bye-word and a reproach.

This failure was due to the combined action of a number of circumstances. Erasmus Darwin was too far in advance of his own contemporaries to meet with a fair appreciation. As Dr. Krause remarks:—"It is only now, after the lapse of a hundred years, that, by the labours of one of his descendants, we are in a position to estimate at its true value the wonderful perceptivity, amounting almost to divination, that he displayed in the domain of Biology."

Again, very much of the evidence that was needed to convince those capable of judging of the truth of Evolution could not be said to exist. The disciplines of animal and vegetable geography, which have supplied such a mass of proof in favour of "Transformism," had not been elaborated. Palæontology was also a thing of the future, and no investigator could point to the gradual mutation, *e.g.*, of *Castanea atava* into *Castanea vesca*, or demonstrate the successive stages through which the horse has passed in reaching his present structure.

Embryology, also, was not in a position to speak as she has since spoken. The collateral evidence in favour of development as the general law of Creation, now furnished by Astronomy in the shape of the nebular theory, was also wanting. What wonder, then, that the system of the elder Darwin, even had it been much more complete than was actually the case, should be rejected?

The time, too, was especially unfavourable. The tele-

ologists were everywhere expounding their favourite dogma of "Man, the measure and the purpose of all things." Foremost among them stood Paley, utterly incapable of rising to any true biological conception, but bold, plausible, and popular, on account of his *à posteriori* demonstration of the existence of God. No small part of his works may be said to have been written at Erasmus Darwin, though the latter is never mentioned by name. Still more unfortunate, in the state of public opinion then prevalent in England, was the fact that Darwin's predecessor, Buffon, and his immediate successor, Lamarck, were both Frenchmen. As such they were at once set down as atheists and "jacobins," and an unmerited and groundless stigma was thus attached to the very idea of Evolution. Dr. Darwin's "Loves of the Plants" was burlesqued by the *Anti-Jacobin* in a humorous effusion entitled the "Loves of the Triangles," and he himself was very openly accused of atheism. The wanton malice or the gross ignorance displayed in this charge must be apparent to all who have taken the trouble to read his works. It would be easy to quote, from the writings of this so-called "atheist," ascriptions of praise and glory to God which almost rise to the fervour and dignity of psalms. But even in our own—as we would fain hope—more candid times we see but too clearly on what slender evidence such accusations are made. Has not the younger Darwin himself been denounced, by some who certainly know better, as the conscious and intentional apostle of infidelity?

A little later on in the century the influence of Cuvier and his school was no less hostile to a candid consideration of the arguments in favour of Evolution. Acute, laborious, and, in some departments at least, a keen and indefatigable collector of facts, the great French professor was wanting in the true philosophic spirit, and tainted to the core with that "aletheophobia" which is the bane of official science. Of him it has been well said that his influence threw back scientific biology for at least one generation.

In England we suffered, in addition, from the predominance of the Quinarian school, as represented by Swainson. Until the atmosphere was cleared of all these mists and clouds no true progress could be effected, and it is therefore no wonder if the clue given by the elder Darwin was neglected and his methods of investigation not followed up.

But we may go further: another cause remains why Erasmus Darwin failed to convince his contemporaries and his more immediate successors, and upon this we cannot

touch without showing wherein he differs from his illustrious grandson.

As Dr. Krause very aptly remarks, "It is one thing to establish hypotheses and theories out of the fulness of one's fancy, even when supported by a very considerable knowledge of Nature, and another to demonstrate them by an enormous number of facts, and carry them to such a degree of probability as to satisfy those most capable of judging." Erasmus Darwin, along with a number of most valuable observations and suggestions, lays before us—as was in his day inevitable—not a few puerile and unfounded hypotheses. Thus he puts in the mouth of a philosophic friend the conjecture that the first insects had proceeded from a metamorphosis of the honey-loving stamens and pistils of the flowers by their separation from the parent plant, after the fashion of the male flowers of *Vallisneria*. He believed that, as far as possible, flowers are adapted for self-fertilisation, and even stigmatises cross-fertilisation as "adulterous." Probably, however, his greatest weakness lies in the agency to which he ascribes the gradual transformation of organisms. Like his successor, Lamarck, he depends here on the conscious and intentional attempts of each being to adapt itself to changing circumstances. He declares that all warm-blooded animals have arisen from one living filament which THE GREAT FIRST CAUSE endued with animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions, and associations; and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity, world without end." This idea is by no means unsuitable as far as animals are concerned; but with strict logical consistency its author applied it also to the development of plants, and thus became, as Dr. Krause maintains, the most formidable critic of his own system. If we are to suppose plants consciously attempting to adapt themselves to changing conditions, we are ultimately driven to assign them a sensorium, and, as the composite vegetable body is not unlike a coral-stock, this sensorium must be ascribed to every bud. These difficulties, it is scarcely needful to say, the younger Darwin evades by his hypothesis of Natural Selection. The individual which—without any intention or consciousness on its own part, and by a mere accidental variation—is in better accord with external circumstances than are its neighbours, has the better chance of surviving them, and of leaving a progeny. Doubting, as we do, the

all-sufficiency of this hypothesis, we must yet admit that it marks out distinctly the interval between Erasmus Darwin and his grandson, and constitutes a most important step in the history of Evolution.

As an introduction to the English version of Dr. Krause's work, Mr. Charles Darwin has contributed a biographical notice of his grandfather, from which we gather interesting facts not a few. He was, for instance, one of the forerunners both of Sanitary Reform and the Temperance Movement, though free from the savour of quackery and the ultraism by which his successors in both make themselves too often unpleasantly notorious. He was a mechanical inventor, no less than a biologist, and his prophecy as to the future career of steam has been too often quoted to need repetition. He refers in his writings to the value of bones as a manure. He expressed the confidence that microscopic research would lead substantially to the discovery of a new world. Two of his sayings here given are worth quoting:—he delared that "the world was not governed by the clever men, but by the active and energetic," and that "the fool is he who never experiments."

But the most interesting feature of this biographical notice is the light which it throws on the interesting question of heredity. For several generations the Darwin family has been distinguished for an intelligence far above the average, which in two cases at least has risen to the rank of genius. Almost all its members have possessed scientific tastes, and have followed the learned professions, generally with success. We read that Robert Darwin, the father of Erasmus, was a man given to scientific pursuits: he left two sons, Robert Waring, a poet and a botanist, and Erasmus, the subject of this memoir. Of the children of the latter five reached maturity:—Charles, who had already become distinguished as an anatomist, when he died from the effects of a wound received whilst dissecting; Erasmus, a statistician and genealogist; Robert Waring, a skilful and eminent physician, father of him whom we must designate as *the* Darwin of our own days; Francis, a naturalist of merit; and Violetta, who became the mother of Mr. Galton, the author of the well-known treatise on the "Heredity of Genius." A son of Francis, Captain Darwin, in his "Gamekeeper's Manual" shows "keen observation and knowledge of the habits of various animals." The two sons of Mr. Charles Darwin, George and Francis, have not merely taken part in their father's researches, but have entered into independent scientific investigations.

By way of contrast to the work with which we have been engaged, we cannot help referring to a review article which has recently appeared on the other side of the Atlantic. We have already glanced, in passing, at the attempts made to find the germs of modern discoveries and speculations in very unlikely regions. At one time it was the fashion to declare that the philosophers and the poets of classical antiquity had anticipated all our most valuable ideas. Next came a rage for extracting systems of science from Hebrew roots by dint of high pressure philology, somewhat as soups of doubtful value may be obtained from old bones by the aid of Papin's digester. The latest mania is for seeking out chemical, physical, or biological truths in the writings of *Albertus Magnus*, St. Thomas Aquinas, or St. Augustine. Indeed St. Augustine is declared to have been an Evolutionist.

The article professes to deal with "Malthusianism and Darwinism." In opposition to the former we are told that the lower races of man die out in contact with civilisation, and thus make room for their superiors. But as against the Darwinians we learn, on the contrary, that it is not the higher, but the lower forms that survive. This, we think, is very like self-refutation.

II. SCIENTIFIC PROGRESS OF THE PAST YEAR.

By William Spottiswoode, D.C.L., LL.D.

(*Being a Condensed Report of the Presidential Address delivered at the Anniversary Meeting of the Royal Society, on Monday, December* 1, 1879.)

In the spring it is our duty to elect into the Royal Society our annual complement of new Fellows, and at our early summer meetings we admit to our ranks the young and vigorous in the career of Science. But in the autumn, or fall, as on the other side of the Atlantic it is so aptly termed, it is our custom to recount the names of those who have dropped from our list. Some of these have fallen in a plenitude of years, and in maturity of mind; others in

that early stage of youth where insight and imagination, as yet scarcely differentiated, have both lent their aid to the first flights of thought.

In looking over the list we are reminded in a striking manner of a fundamental difference between the Royal Society and the Academies of the Continent, a difference which may perhaps be the best described by the term "comprehensiveness." For, beside the class of Fellows selected, in accordance with our recent legislation, from the members of the Privy Council, it has always been our custom to gather into our ranks not only men of eminence in Science proper, and in subjects which border on it, but also men of distinction in other paths of life, provided that they have followed those paths on principles which are analogous to our own, and which by no undue strain of the analogy may themselves be called scientific.

In illustration of this remark, I might point in the present list to the man of letters, to the architect, to the politician, to those who have honourably served in various departments of the public service, to the man of wealth who has turned his large means to large-minded purposes for the welfare of the people. And although the act of erasing them from our list marks our loss, yet the fact of having once reckoned them among our number is in itself a gain, and must help to enlist the sympathies of the world outside in our special function, viz., the promotion of natural knowledge, while at the same time it tends to enlarge our own.

To mention briefly a few of these :—In Sir James Matheson we have lost a wealthy and enlightened member, who devoted much of his time, his energy, and his means in promoting the welfare, both moral and intellectual, of the people among whom he made his home.

In the Marquis of Tweeddale we have an instance, happily not singular, of one who, without any professional connexion with the subject, contrived amidst the distractions of active service to lay the foundations of a solid knowledge of one branch of science; while in later years he became an active collector and the author of valuable contributions to the publications of the Geological Societies over which he presided.

In the category of men of cultivation and leisure, who have turned their attention with good purpose and success to scientific pursuits, we may fairly reckon our late Fellow John Waterhouse, of Halifax.

Sir Thomas Larcom was one of a long series of distinguished men who have been elected Fellows of the Royal

Society from the Corps of the Royal Engineers. Travelling beyond the strict limits of his professional career, he endeavoured to give to his official work a wider range. And it was due to suggestions emanating from him that the Irish Survey was so extended as to make it the opportunity for collecting a great variety of local information, history, language, and antiquities, and that the map became the admiration of scientific travellers.

Mr. Bennet Woodcroft's name will always be associated with the foundation of that important department the Patent Office, with its Library, and Museum, of which he was the first executive officer.

Professor Kelland and Mr. Brooke were among our veterans in the Society, and many of us will long recollect the lively interest in Science which the latter showed during his frequent attendance at our evening meetings.

In Mr. W. Froude, to whom one of the Royal Medals was awarded in 1878, the Society, the public service of the country, and Science in general have sustained a loss which at one time would have been irreparable, and which even now, when his work has become an established science, is difficult to replace.

Of Professor Clifford, and the gap which his death has caused among our friends and the world of science at large, I know not how to speak. His mathematical papers are being collected by a careful and trusty hand, while his philosophical remains have been given to us by one who knew and loved him as he deserved. To the same friend we owe the memoir of his life, written indeed so far as that life can ever be written, but reminding us also at every line that his life was one the full story of which will always seem but half told.

If in Professor Clifford we have lost one of our youngest, in Sir J. G. Shaw-Lefevre we have lost one of the oldest of our mathematical Fellows. Born before the present century, and Senior Wrangler at Cambridge before many of us were in existence, he seems to belong to a past age. But through a long and honourable course of unusually varied and responsible public life he always retained his interest in mathematics, and, himself no mean geometer of the old school, he had in his later years projected and actually begun a new edition of the works of Archimedes. Of his labours in connexion with University College, and afterwards with the University of London, all who are interested in liberal education will retain an appreciative and grateful memory.

Our last loss, that of Professor Clerk Maxwell, has been

in some respects the greatest. In him the full maturity of a mind which had suffered no check or shadow of abatement, was devoted to the foundation of a more thorough knowledge of Molecular Physics and of Electrical Laws than has hitherto been attained. The clear insight, the keen criticism, the just and liberal appreciation of the views of others, evinced both elsewhere and especially in his Reports to the Committee of Papers, will long be remembered; while the more general side of his character, exemplified in the numerous scintillations struck off with his pen, will be no less cherished by those to whom his scientific writings were as a sealed book. To replace such a man seems at first impossible: but we should be doing scant justice to his memory if we did not believe that the good seed which he so liberally sowed would bear such fruit that in the time of need there should be no lack.

* * * * * *

An extra volume of the "Philosophical Transactions" (vol. clxviii.) has been issued, in which the observations made by the naturalists who accompanied the Transit of Venus Expeditions to Kerguelen's Land and Rodriguez, and descriptions of their collections by persons specially acquainted with the several subjects are brought together. The volume is divided into four sections, viz., the Botany and Zoology of each of the two islands respectively.

The Botanical collections from Kerguelen's Land, worked out by Sir J. D. Hooker, Mr. Mitten, the Rev. J. M. Crombie, Dr. Dickie, P. F. Reinsch, and the Rev. M. J. Berkeley, have added largely to our knowledge of the Cryptogams, especially the Algæ. In particular the American affinity of the Kerguelen Flora, previously established by Sir J. D. Hooker, in his examination of the flowering plants, is proved to be also very strongly manifested in the Cryptogams.

Of the Zoological collections from Kerguelen's Land those of the Mollusca, Crustacea, Arachnida, and Insecta have yielded the greatest number of novelties; the two former offering distinct evidence of the affinity of this Fauna (as of its Flora) with that of South America. The Arachnids and Insects of the southern extremity of America are unfortunately too little known at present to admit of a comparison with the highly interesting new forms discovered by Mr. Eaton, and described in this section.

In estimating the affinities of the Flora and Fauna of Rodriguez the authors were under great difficulties, owing to our imperfect knowledge of the plants and animals of the other Mascarene Islands. But almost all their observations

point strongly to the conclusion that the present animals and plants are the remains of a once more extensive Flora and Fauna which has been gradually broken up by geological and climatic changes, and which more recently has been greatly interfered with by the agency of man. The greater portion of the botanical section has been undertaken by Dr. Is. Bayley Balfour, who himself collected the materials. He estimates the total number of plants found at present in Rodriguez at 470 species, viz., 297 Phænogams and 173 Cryptogams; and he establishes the remarkable fact that of the Phænogams not less than 108 are to be regarded as introduced into the island, and that 189 only are indigenous. Great interest attaches to remains of the extinct cave-fauna of Rodriguez; and the collection made by Mr. Slater supplied materials for three papers, by Mr. E. Newton, Mr. J. W. Clark, and Dr. Günther. With regard to Zoology, the marine collections were those to which least interest was attached, as they consisted principally of common forms spread over the whole of the tropical Indian Ocean. On the other hand, our knowledge of the Terrestrial Invertebrates received considerable additions, especially in the Myriopods and Arachnids, Coleoptera and Turbellaria, described by Mr. A. G. Butler, Mr. C. O. Waterhouse, and Mr. G. Gulliver.

The papers presented to the Society, and read at our evening meetings, have been more numerous than in any previous year of our existence, and have during the last twelve months reached a total of 118. Some of them appear to have excited unusual interest among the Fellows and their friends, for on more than one occasion our meeting-room was filled to an almost unprecedented degree.

But, beside the interest attaching to their reading and discussion, the papers themselves have offered some very striking features. It would be as invidious to attempt, as it would be impossible to establish, any general comparison of merit among so varied a collection of memoirs; but I may still be permitted to take this opportunity of expressing my own impressions of a few which fall, more or less, within my own range of study.

In purely experimental research—that is, in experiments guided by a clear conception of what was wanted to be done, and executed with adequate instrumental appliances and with the highest manipulative skill—we cannot but be struck by the assiduity and success with which Mr. Crookes has continued his labours. He has now brought to a termination his remarkable series of papers on "Repulsion

resulting from Radiation," and has already struck out into a new region, viz., the study of certain Electrical Phenomena which appertain especially to high vacua. In the vacua to which he has now turned his attention the exhaustion has been carried even beyond that in which the phenomena of the Radiometer are produced, and it is by a legitimate and sagacious step that he has now occupied a complete field of inquiry intermediate to the most extreme vacua ever attained, and those in which the stratified discharge is displayed. Of the delicacy and beauty of the experiments it is not necessary here to speak, for they have been already exhibited here, as well as to more than one audience on a large scale. Through this advance on his part a helping hand will doubtless be held out to those who are occupied with the subject of stratification, for in this matter the two advancing powers desire neither a "neutral zone" nor a "scientific frontier" to separate their field of action.

Another communication, full of promise as well of performance, should also not pass unnoticed. I allude to Prof. Hughes's paper on his Induction Currents Balance, the application of which has already branched out and borne fruit in more than one direction. The extreme simplicity of the instruments, and their marvellous adaptation to the purposes for which they were intended, reflect the highest credit on their inventor.

Not unconnected with Mr. Crookes's researches, so far as they are directed towards the ultimate constitution of gases, are those of Prof. Osborne Reynolds. In his remarkable paper "On Certain Dimensional Properties of Matter in a Gaseous State" Prof. Osborne Reynolds has established the fact of what he calls Thermal Transpiration, namely, that when two portions of the same gas are separated by a porous plug, the two surfaces of which are at different temperatures, the condition of equilibrium is no longer that the pressures of the gas on the two sides of the plug should be equal, but that the pressure on the hotter side should exceed that on the colder side by a certain quantity; and that if this is not the case, the gas will transpire through the plug until this condition is satisfied. Prof. Reynolds connects this principle with Mr. Crookes's Radiometer experiments; and the various considerations which he brings to bear on the subject appear to have this idea throughout, that the dynamical similarity of two gaseous systems, bounded by solid surfaces, geometrically similar, depends on the ratio of the homologous lines of the system to a certain quantity, having the dimensions of a line, and which varies inversely

as the density of the gas. Although dimensional considerations have been shown by previous writers to have an important bearing on the Theory of Gases, still his experimental results form an important contribution to our knowledge of the subject; and in his theoretical investigation he has attacked with vigour, and not without success, some elements of the problem avoided by his predecessors in this field of research.

Photography has of late years become so completely the handmaid of Physical Science, and has so constantly responded to the calls of its master, that its progress, however rapid and however effective, has come to be taken almost as a matter of course. But the step which Captain Abney appears now to have taken lies entirely out of the ordinary line of advance. M. Becquerel, as is well known, succeeded some years ago in producing natural colours by the agency of light, one specimen of which—a solar spectrum—was given to me some three years since by M. Cornu, and which, through being carefully preserved in a tin box, retains all its chromatic features. Captain Abney has now taken up the subject again, and believes it probable that the colours obtained by this process may be preserved unchanged when exposed to ordinary daylight. His suggestion as to the physical causes of the colour is interesting, and leads us to hope that we may hear more upon the subject.

It was at one time thought that Science and practical life were essentially distinct, and that in their cares and their purposes, in their sorrows and their joys, neither intermeddled with the other. But in proportion as it has been gradually recognised that Science, and even Philosophy itself, is based upon experience, so has their distinction gradually faded from our view. And, among many other instances of forecasts in this direction by far-seeing men, I may adduce the dream of Babbage, that mathematical calculation might be reduced to mechanism, and that the data of many problems both of physics and of life might be handed over to an engine which would work out the results. That dream of his was as nearly realised as any dream of his ever could be realised; for the merit and the charm of the man himself, and the fascination which he threw about all his projects, were derived from the fact that, at whatever rate realisation followed, his ideas flew faster and faster still and outstripped them all. And if, in the machinery for complicated calculation designed by the Brothers Thomson, much more has been actually achieved than ever before, it

is not because this is a generation of more feeble folk, or because there has been any lack of elasticity of mind or of fertility in idea, but because their minds and their ideas have been more under control, and because these men have succeeded in that which their great predecessor always missed, namely, mastery over themselves.

The relations between the Mechanism of the Heavens and the History of the Earth have for some years past been the subject of speculation and of argument amongst many prominent men of science. And calculations have been made, tending more or less to confirm the views of the various writers on the subject. But so vast is the problem, so multifarious in its data, so complicated in its laws, that eager as we are to grasp anything solid or well founded in the inquiry, we are constantly left with a feeling that we may have clutched at a mere floating weed, when we hoped that we had laid hold of something firmly rooted. And on this account we may look with unusual satisfaction at the massive and philosophical research in which Mr. George Darwin is engaged, and of which we have already some substantial instalments. It consists in an investigation on the precession and tides in a viscous spheroid, in which he applies his results to a discussion of the internal condition of the several planets, and of the evolution of the moon and other satellites from the primitive nebulæ.

I now pass on to mention briefly a few other subjects which, outside our immediate sphere of action, form substantial elements of the scientific progress of the past year, and among these I should first mention Meteorology, because the Council, to whom in this country the subject is entrusted, is nominated by the Royal Society.

The science of Meteorology has, during the last few years, attracted an increasing amount of attention, more perhaps from its close relation to the interests of all classes of the community than from the definiteness or novelty of the scientific results to which it has led.

The second International Congress of Meteorology met at Rome in April of the present year, on the invitation of the Italian Government; an interval of nearly five years having elapsed since the date of the first Congress, which was held at Vienna in 1874. The main object of these meetings has been to introduce greater uniformity of method into the meteorological systems of Europe, without attempting, however, to pledge the different Governments to any definite engagements on the subject. With this view a permanent International Committee has been constitued, to

furnish a *point d'appui* for common action, and to facilitate, during the intervals between the Congresses, a personal interchange of opinions among the authorities directing the different systems.

A great number of valuable reports, on questions embracing nearly the whole field of Meteorology, were received by the Roman Congress. Among them, special mention may be made of the reports by M. Violle on Solar Radiation; by M. Pernet, on the Determination of the Fixed Points of Thermometers; and by Prof. Everett, on Atmospheric Electricity.

A Conference of a semi-official character, which was originated by the Congress at Rome, was held at Hamburg in the beginning of October, for the purpose of taking into consideration a proposal, emanating from Lieut. Weyprecht and Count Wilczek, to establish for one complete year a circle of meteorological observations round the Arctic regions of the globe. The Conference was attended by representatives of the Meteorological Institutes of Austria, France, Germany, Russia, and the Scandinavian countries; and it was agreed that an effort should be made to establish the proposed circumpolar system of meteorological and physical observations in the year 1881. Some part at all events of this plan will, in all probability, be carried into effect, as the Canadian Government has intimated its readiness to co-operate in it, and as Count Wilczek has offered himself to defray the cost of an Observatory at Nova Zembla.

The unfavourable weather which has characterised the present year has given an additional impulse to the study of English Meteorology: and our own Meteorological Office has ventured to resume the issue of Daily Forecasts of Weather, after they had been discontinued for nearly thirteen years. The attempt has been made under somewhat adverse circumstances, as the uncertainty of the weather of 1879 has even surpassed the proverbial fickleness of the British climate. But the experiment has been liberally supported by the Press, and has been watched with great interest by the public generally. Of its success or failure it would as yet be premature to speak, but it deserves recognition as a serious attempt to apply to one of the most uncertain of the sciences the severe test of prediction.

Transit of Venus (1874) *Reductions.*—The calculations of every kind relating to the five British Expeditions were some time ago concluded. The mass of them refers to the determinations of terrestrial longitudes and the discussion of the measurements of photographs. The preparation of

the Astronomical (as distinguished from the Photographic) Observations and Results for Printing is complete for the expeditions to the Hawaiian Islands, Rodriguez Island, and New Zealand. For the other two expeditions much remains to be done—chiefly, however, mere copying. The employment of the staff upon the measurement, re-measurement, and discussion of the photographs, was the most serious cause of the delay that has occurred in presenting to the public the astronomical results. Those who are now engaged upon this subject entertain serious doubts as to whether any result of value, as regards the special object of the expeditions, is to be expected from the photographs, owing to a want of sharpness in the images. Some of the photographs taken by the Russian Astronomers* have been measured, but not very successfully. The telescopic observations of the internal contacts, at many stations in India and Australia, as well as at those occupied by the Government Observers, in all thirty-one observations of the *Ingress* and forty-eight of the *Egress*, have yielded a value of the mean solar parallax of $8''{\cdot}85 \pm 0''{\cdot}03$.†

The Greenwich Nine-Year Catalogue of 2263 stars, with discussions of the systematic errors of R-A.'s and N.P.D.'s has been published.

The complete reduction of the measures of about 1900 photographs of the sun, taken at Greenwich from 1873 up to the present time, affords data immediately available for determining the distribution of spots and faculæ on the sun's surface, and the position of its axis of rotation. The photographs now regularly taken at Greenwich may be considered a continuation of the Kew series.

The reduction of the Greenwich magnetic observations, 1841—1877, has afforded an opportunity for testing the connexion (first suggested by Sir E. Sabine and afterwards investigated as regards the element of declination by Professor R. Wolf) between magnetic variations and sun-spots. Mr. Ellis has compared the diurnal ranges of magnetic declination and horizontal force with Professor Wolf's curve of sun-spot frequency, with the result that not only is there a general correspondence in the two sets of phenomena, but the minor irregularities of the sun-spot curve are reproduced in the curves of diurnal magnetic range for both elements, and further that the well-marked annual inequality in the latter is itself variable, being greatest at the time of maximum of sun-spots and least at that of minimum.

* At Haven Possuit.

† "Monthly Notices, R.A.S.," xxxviii., p. 455.

The spectroscopic determination of the motions of stars in the line of sight by the displacement of lines in their spectra, has been recently extended at Greenwich to stars of the third and fourth magnitude, raising the number of stars available for the application of this method to 200 or 300. Up to the present time, the motions of 63 stars have been thus determined at Greenwich. Mr. Seabroke, at Rugby, has also applied the method to 28 stars, and his results, though presenting some discordances, *inter se*, generally support those obtained by Mr. Huggins and by the Greenwich observers.*

A new determination of the Figure of the Earth, in which the results of recent measurements of the Indian arc of 24° are included, has been made by Colonel Clarke.†

A connexion between the Sun's Outer Corona and Meteor Streams has been suggested by several observers, Professor Cleveland Abbé, Mr. F. C. Penrose, and others,‡ of the Solar Eclipse of 1878.

From a discussion of the distribution of aphelia and inclinations of cometary orbits, Professor H. A. Newton has come to the conclusion that comets have come to us from the stellar spaces (in accordance with Laplace's hypothesis) and that (with the possible exception of the comets of short period) they have not originated within the solar system as Kant supposed.§

Mr. Gill has deduced from his extensive series of Heliometer Observations of Mars at Ascension, the value $8''{\cdot}78 \pm 0''{\cdot}015$ for the Sun's mean Equat. Hor. Parallax.‖ This agrees nearly with the first published result of the British Transit of Venus Expeditions, and also with the result of Cornu's determination of the velocity of light combined with Struve's constant of aberration.

The publication of Lohrmann and Schmidt's Maps of the Moon forms an important contribution to Selenography.

M. Flammarion has published a valuable Catalogue of Binary Stars, giving all available observations (to the number of 14,000) of these objects, with the elements of their orbits, so as to present a complete summary of their history.

Among the more recent Institutions for the promotion of Science, mention should be made of the Observatories

* "Monthly Notices," 1879, June. 1879, October 10.
† "Phil. Mag.," 1878, August.
‡ "Monthly Notices," 1878, November.
§ "Amer. Journ.," 1878, September.
‖ "Monthly Notices," 1879, June.

for the study of Astronomical Physics in France and Germany.

The elder of these in point of date, namely that in France, although founded in 1876, has only quite recently been permanently established in the Chateau at Meudon. The Director has ever since the foundation been principally occupied with solar photography, and he has established the fact that photography is capable of revealing phenomena which must necessarily escape ordinary telescopic observation. In particular, he has succeeded in photographing the granulations previously seen on the solar disk by other astronomers; and by means of his magnificent pictures, one of which he has recently presented to the Society, he has established the existence of what he terms the *Réseau photosphérique;* in other words, that the surface of the sun is divided into regions of calm and of activity. His present researches will doubtless enrich our knowledge with many new facts.

The German Observatory has been placed at Potsdam. In the selection of the locality, 320 feet above the sea, with a good horizon, and free from the smoke and vibration of the city, and in the furnishing of the Observatory, the German Government has done everything that could be wished. And it may confidently be hoped that in the hands of Professor Vogel and his colleagues much good work will be there done.

The ramifications of Science are now so various in direction, so comprehensive in grasp, and so immediate in their applications, that they have of late years given rise to the establishment of special Institutes and Societies for the study and encouragement of their respective subjects. Among these there may be mentioned the Society of Telegraph Engineers, the Iron and Steel Institute, and others.

At the meetings of these bodies it frequently happens that subjects which may have, in their primary form of a scientific discovery, been laid before the Royal Society, are brought up again and discussed from a different point of view, *e.g.*, in their relation to other subjects, or in their application to the special purposes of life. For instance, in the "Proceedings of the Society of Telegraph Engineers" we find the following:—

1. Wires which run parallel to each other for a long distance are very much troubled by induction between wire and wire. The effect on telegraphs is to diminish speed of working, and on telephones to render speaking impossible. Hughes has studied these effects in his own peculiar way and has shown how, when the number of wires is limited

and the working confined to one direction, they can be entirely eliminated.

2. Mr. Cowper has shown how, by producing the two rectangular components of a plane curve at a distance, it is possible to reproduce handwriting. His instrument works very effectively, but is still perhaps in an early stage of its development.

3. The application of the Duplex system to long cables has been practically and very efficiently carried out by Mr. Stearns on the Atlantic Cable, and by Mr. Muirhead on the long cables of the Eastern Telegraph Company in the Mediterranean and Indian Ocean.

4. The Electric Light is still on its trial for general street illumination in Paris and London; but it has been recently very effectively employed in surveying and sounding the Mediterranean by night, and in the operation of laying and repairing cables by the steam-ship "Dacia," belonging to the Silvertown Company. By its aid ninety-six soundings, made with Sir William Thomson's steel wire apparatus, in water averaging 1500 fathoms depth, were taken in seven days and nights, bottom in every case being brought up.

5. Several improvements in Telephones have been brought out, notably Gower's, in Paris, and Edison's loud-sounding arrangement, and the instruments are gradually finding their way into practical use.

6. Experiments are being made both in England and in France in the transmission of mechanical power by electric currents; and we may hope for valuable results from this field of inquiry.

The Iron and Steel Institute was founded in 1869 under the presidency of the Duke of Devonshire. The Society consists of proprietors and managers of iron and steel works, of metallurgical chemists, geologists, and engineers. The number of its members has grown gradually from 140 at its commencement to its present limit, 1031, of whom 116 are foreigners residing abroad, and comprising the leading metallurgists of America as well as of the continent of Europe. The Association meets twice a year, once (during the spring) in London, and once (in the autumn) by invitation at one of the great industrial centres in England or abroad. In 1873 it met at Liège, in 1878 at Paris, and in 1880 it will meet at Düsseldorf. Each meeting lasts from two to four days, which are spent partly in reading and discussing papers, and partly in visiting works of interest.

The results of the Association have been of considerable utility: (1) by bringing the scientific metallurgist into con-

tact with the man of practical experience, thereby extending the appreciation, and in many instances even the actual cultivation, of Science; (2) by the annual publication of a very valuable record of the progress made in this important branch of applied Science; (3) by acting as a kind of international tribunal on the merits or demerits of new processes, in a manner calculated both to stimulate and to guide further undertakings.

Telegraph Conference.—When Telegraphy began to assume an international character, great inconvenience arose from want of uniformity in the apparatus used, and in the service regulations adopted by different European countries.

Although the construction of the line (whether submarine, underground, or suspended) and the details of construction of the telegraphic apparatus employed may fairly be left in the hands of each country or telegraphic administration, it was soon found to be necessary that a certain standard of efficiency should be insisted upon. Agreement was moreover requisite in regard to the general character of the instruments to be used in international telegraphy; for instance, whether or not acoustic signals were to be admissible, whether an indelible record should be insisted upon, whether a type-printer, or an autographic instrument should be used, or a recording instrument representing the letters by dots and dashes, in which case a uniform code would be a matter of necessity. Beside these points there remained the subject of the tariff to be charged in each country for transit and terminal messages, involving delicate questions, which could be settled only by mutual concessions and general arrangements.

These considerations led the French Government, in 1866, to invite those European Governments who had already taken the administration of the telegraphs in their own hands, to meet at Paris, in order to agree if possible on certain resolutions, subject to ratification by the respective Governments. England was not represented at this first Conference, because the telegraphs were not yet a Government Department, and it was not thought advisable to invite telegraph companies to take part in the proceedings.

The result of the first deliberations went beyond the mere settlement of pressing questions, and it was decided to hold periodical Conferences at the different capitals of Europe, and to institute a central International "Bureau" (to be located at Berne) to see to the proper application of the resolutions of the Conferences, and to act as an International

Court of Appeal, regarding questions of difference in telegraphic matters arising between the contracting countries.

The second Conference took place at Vienna in 1869, in which several countries, including Turkey, Persia, and British India, took part for the first time. On this occasion it was resolved that the leading telegraph companies should be admitted to the discussions, but should not be allowed to vote; the power of voting being confined to the Governments, and each country having one vote only, irrespective of its size and importance.

The third Conference was held at Rome in December, 1871, when the British Government (Post Office) was for the first time represented, and also the Indo-European and Cable Companies, which latter are bound by the resolutions of the Conference only in matters of international administration, and of tariff in cases where lines join two countries belonging to the Union.

The fourth Conference met at St. Petersburg in 1876, and the fifth at London in 1879. At the latter meeting difficult questions of tariff arose, which protracted the sittings over nearly two months. At previous Conferences it had already been decided to treat each country as a unit, its particular charge being the same, whether a message had only to cross the frontier or had to pass over long distances into the interior. At the London Conference it was proposed by Germany to adopt a uniform rate per international message for the whole of Europe, analogous to the uniform postal rate for letters, while France went further and urged the adoption of a universal *rate per word*. Neither of these measures, however, was adopted, but a compromise was effected: and after the 1st April, 1880, each word will be charged at a specified rate for each country, five words being added to each message to cover time spent in advising, commencing, and finishing it.

All European countries, as well as Brazil, Persia, India, and Japan, belong to the Conference, and are bound by its decisions.

Any of twelve modern languages using the Roman character may be employed; Russian, Greek, Turkish, being thus excluded from use.

It would be difficult to over estimate the beneficial results produced by these Conferences in stimulating and perfecting international communication.

Material is not wanting to extend these notices of scientific activity over a wider range; for our foreign neighbours are always ready to furnish us with information of whatever is

new among them either in matter or in method. But a mere enumeration of these things, however interesting in themselves, would form but a dull chapter, unless it should issue in a judicial estimate of results, or a suggestive comparison of national arrangements for the promotion of science. On such an enterprise I am by no means prepared to adventure myself; and even if I should be ever led to make the attempt on some special topic, or some particular aspect of the question, I must, at all events, defer it to a future occasion.

The Award of the Royal Society Medals.—The Copley Medal has been awarded to Rudolph Julius Emmanuel Clausius, Foreign Member of the Royal Society, for his investigations in the Mechanical Theory of Heat.

The Mechanical Theory of Heat as at present understood and taught has been so essentially a matter of growth, that it would be difficult to assign to each investigator the precise part which he has taken in its establishment. It will, however, be admitted by all, that the researches of Clausius rank high among those which have mainly contributed to its development. These researches extend over a period of thirty years, and embrace important applications of the theory not only to the steam engine, but to the sciences of electricity and magnetism.

Even to enumerate those who have contributed to one branch of the subject, viz., the Kinetic Theory of Gases, would be beyond my present purpose and powers; but as Clausius himself states, both Daniel and John Bernoulli* wrote on the subject. And, even, to go back to earlier times, Lucretius† threw out the idea; while Gassendi, and our own Boyle, appear to have entertained it. Within our own recollection, Joule, Meyer, Kroning, Clerk Maxwell, and others have made invaluable contributions to this branch, as well as to the general subject of the Mechanical Theory of Heat. But however great the value of these contributions, it may safely be stated that the name of Clausius will always be associated with the development of earlier ideas into a real scientific theory.

A Royal Medal has been awarded to W. H. Perkin, F.R.S. Mr. William Perkin has been, during more than twenty years, one of the most industrious and successful investigators of Organic Chemistry.

Mr. Perkin is the originator of one of the most important

* In the 10th section of his "Hydrodynamics."

† "De rerum Naturâ," lib. ii, 111—140.

branches of chemical industry, that of the manufacture of dyes from coal-tar derivatives.

Forty-three years ago the production of a violet-blue colour by the addition of chloride of lime to oil obtained from coal-tar was first noticed, and this having afterwards been ascertained to be due to the existence of the organic base known as aniline, the production of the colouration was for many years used as a very delicate test for that substance. The violet colour in question, which was soon afterwards also produced by other oxidising agents, appeared, however, to be quite fugitive, and the possibility of fixing and obtaining in a state of purity the aniline product which gave rise to it, appears not to have occurred to chemists until Mr. Perkin successfully grappled with the subject in 1856, and produced the beautiful colouring matter known as aniline violet, or mauve, the production of which, on a large scale, by Mr. Perkin, laid the foundation of the coal-tar colour industry.

His more recent researches on anthracene derivatives, especially on artificial alizarine, the colouring matter identical with that obtained from madder, rank among the most important work, and some of them have greatly contributed to the successful manufacture of alizarine in this country, whereby we have been rendered independent of the importation of madder.

Among the very numerous researches of purely scientific interest which Mr. Perkin has published, a series on the hydrides of salicyl and their derivatives may be specially referred to; but among the most prominent of his admirable investigations are those resulting in the synthesis of coumarin, the odoriferous principle of the tonquin bean and the sweet scented woodruff, and of its homologues.

The artificial production of glycocol and of tartaric acid by Mr. Perkin conjointly with Mr. Duppa, afford other admirable examples of synthetical research, which excited very great interest among chemists at the time of their publication.

It is seldom that an investigator of organic chemistry has extended his researches over so wide a range as is the case with Mr. Perkin, and his work has always commanded the admiration of chemists for its accuracy and completeness, and for the originality of its conception.

A Royal Medal has been awarded to A. C. Ramsay, F.R.S. Professor Ramsay has been for a period of nearly forty years connected with the Geographical Survey of Great Britain,

and during by far the greater part of that time either as Director or Director-General of the Survey. During this long period, in addition to his official labours in advancing our knowledge of the geology of this country, he has published works on the "Geology of Arran," "The Geology of North Wales," "The Old Glaciers of North Wales and Switzerland," and "The Physical Geology and Geography of Great Britain," now in its fifth edition. His papers in the "Quarterly Journal of the Geological Society," and elsewhere, are numerous and important, especially those on theoretical questions in physical geology, such, for instance, as "The Glacial Origin of Lake Basins," "The Freshwater Formation of the Older Red Rocks," and "The History of the Valley of the Rhine, and other Valleys of Erosion." There are, indeed, among living geologists few who can claim to have done more to extend our knowledge in the important fields of geology and physical geography.

The Davy Medal has been awarded to P. E. Lecoq de Boisbaudran. The discovery of the metal gallium is remarkable for having filled a gap which had been previously pointed out in the series of known elements. Mendelejeff had already shown that a metal might probably exist, intermediate in its properties between aluminium and indium, before Boisbaudran's laborious spectroscopic and chemical investigation of numerous varieties of blende led him to the discovery and isolation of such a metal.

The separation of the minute traces of gallium compounds from blende is an operation presenting unusual difficulty, owing to the circumstance that compounds of gallium are carried down by various precipitates from solutions which are incapable by themselves of depositing those compounds.

III. THE HON. HENRY CAVENDISH: HIS LIFE AND CHARACTER.

IF there is one scriptural admonition which the scientific workers of the present day fail to obey more rarely than another, it is the one which warns us against the foolishness of hiding our light under a bushel, instead of setting it on a hill so that it may shine before all men.

Every discoverer, now-a-days, whether great or small, as soon as he finds his light,—whether it be a six-thousand-candle electric lamp or only a halfpenny dip,—immediately hastens to place it on the top of the tallest hill he can find, so that it may shine forth literally *urbi et orbi*. Many lights, it is true, give forth only a feeble glimmer; but it is surely better that we should be at times overburdened with crude observations of possibly valueless facts, than that a single particle of truth should be concealed, or its publication delayed even for a day more than is absolutely necessary.

There never was a period in the world's history when scientific observation was so universal as in the present year of grace, and it never before had such a chance of being so thoroughly controlled by publication and criticism. An important discovery in any branch of physical science is now made public with a rapidity that has never before been equalled, and the paper, article, or even telegram containing its history is published and re-published, discussed and criticised, in every civilised language. The observations described are repeated and tested in half a hundred laboratories, and the slightest incorrectness or mis-statement is pounced upon with the utmost eagerness, and published with the same universality as the original researches themselves. The numerous facilities which we possess for spreading and sifting scientific observations are bearing fruit every day, and the scientific press—although its office is to collect and distribute facts rather than to criticise them—has become as great a power in its own particular sphere as its elder sister, the political press, has in the hands of our political fellow-workers.

We have been led into making these remarks upon the great publicity which is now given to scientific researches by a perusal of the excellent sketch of the great Cavendish's life and character, which serves as an introduction to the collection of his electrical researches,* the principal of which are now published for the first time through the liberality of the University of Cambridge. The work has been edited by and brought out under the direction of the late Prof. James Clerk Maxwell, who was lost to science almost before the ink of the last proof was dry. It is indeed a striking example of the fitness of things that these hitherto

* The Electrical Researches of the Honourable Henry Cavendish, F.R.S. Written between 1771 and 1781. Edited, from the Original Manuscripts in the possession of the Duke of Devonshire, K.G., by J. CLERK MAXWELL, F.R.S. Cambridge University Press. London: Cambridge Warehouse, 17, Paternoster Row.

hidden documents should have been given to the world as the last labour of a modern scientist who united in his own person the same extended mathematical knowledge and power of acute and accurate observation as was possessed by the philosopher whose researches he has so ably edited. It is also equally fitting that the late Prof. Maxwell should, at the time of his death, have been the first Cavendish professor at the laboratory founded at Cambridge by the present Duke of Devonshire, in memory and in honour of his illustrious kinsman.

The Hon. Henry Cavendish was the eldest son of Lord Charles Cavendish, third son of the second Duke of Devonshire, whose family can be certainly traced back to the reign of Edward III., and with great probability to that of the Conqueror. This fact is worthy of notice seeing that, besides Robert Boyle, Henry Cavendish was the only scion of our English nobility who left his mark on Science. He was born at Nice (then in Italy) in 1731, and died at Clapham in 1810. Although he had nearly reached eighty years of age at the date of his death, we know less of his sayings and doings during that long period than we do of those of any other modern philosopher of comparable eminence during a quarter of that time, and this for a simple but sufficient reason that will presently appear. From the few particulars that can be gathered about him from his contemporaries—for his own journals, papers, and correspondence throw little or no light on the matter—Cavendish appears to have been the very incarnation of shyness, a quality which seems to have imbued his whole life so thoroughly as to easily account for all his oddities and eccentricities, and to have finally rendered him a perfect type of a passionless, viceless solitary. The first we hear of him in connection with the work-a-day world is in 1755, when, after three years' study, he left Cambridge without taking his degree and the honours to which his transcendent abilities would have entitled him. This piece of eccentricity is referred by some of his biographers to his conscientious objection to sign the then necessary religious declarations; but as he never gave the slightest sign of having either a conscience or a religion, we think it more consistent to ascribe his flight to his ruling passion, if, indeed, so strong a term can with any propriety be applied to so passive a defect as shyness.

During the first twenty years after quitting Cambridge he appears to have lived at his father's house in Great Marlborough Street; but here again all personal particulars are

wanting beyond the fact mentioned by himself in one of his papers, that he worked in a back and fore room, one of which was 14 feet high,—a description which, meagre as it is, puts out of court those of his biographers who assert that he lived in a set of stables fitted up for his accommodation. During this period his father, who was a comparatively poor man, allowed him £500 a year. The smallness of the allowance is supposed by some to have been the cause of Cavendish's habits of economy and oddities of character; but this is equally untenable. Riches and poverty are only relative, and the passionless philosopher—whose apparatus was chiefly made of glass plates, wire, tinfoil, cardboard, and firewood—must in those days have been fairly comfortable on such a sum. It is stated that the so-called meagreness of his annuity was owing to his father's displeasure at his refusal to enter public or professional life: whether this be so or not it is impossible to know now, but the fact nevertheless remains that Lord Charles was a poor man considering his high connections. He was a man of Science of no mean ability; and although we have no means of knowing upon what terms he lived with his son, he must have appreciated his superior genius. Somewhere about 1773, about ten years before his father's death, Cavendish appears to have come into a large fortune of several hundred thousand pounds, but the source or sources of it are unknown, except we admit the hackneyed "rich uncle from India" theory. This fortune he added to, by his inability to spend, so considerably during the remainder of his life that he died worth a million and a quarter sterling.

He now seems to have removed to Montague Place, Russell Square, and to have taken a country house at Clapham, where he died. His wealth seems to have made no change in his habits; he still remained the silent investigator, dragging secret after secret out of his ricketty apparatus, and carefully hoarding it up. His wonderful habits of precision, however, compelled him to make careful notes of all that he did, and it is from these notes that we know most of his greatness as an electrician. The twenty odd packets of essays and papers—most of them carefully prepared for reading or printing, but never published—were placed in the hands of Sir W. Snow Harris by the present Duke of Devonshire when Lord Burlington; but this "valuable mine of results," as they are called by Sir William Thomson, to whom they were shown in 1849, has been unworked till now. As we are not reviewing Prof. Maxwell's work at

present, we must refer to its pages those of our readers who wish to assay these long-concealed nuggets. The collection was partly used by Dr. Grange Wilson in his "Life of Cavendish, written in 1851 for the Cavendish Society, and referred to by Sir W. Snow Harris in his work on "Frictional Electricity" published in 1867, but Sir William did not live to edit them. Under these circumstances the Duke of Devonshire, to whom they belong, placed them in Prof. Maxwell's hands in 1874, with the interesting results that we see. These details are necessary as showing the care with which Cavendish hoarded the written accounts of his labours, which, had they been published in due time, would have added still brighter rays to the already brilliant crown of light that hovers over his name. Investigation was his joy; publication his cross, for it wounded his shyness in its tenderest spot. He undertook the most laborious researches to clear up difficulties and doubts of whose existence and scope he alone was cognisant. The pleasure—his unique one—of solving these problems he must have enjoyed alone, insensible to the desire of communicating their solutions to his fellow men, which appears to have more or less ruled the actions of philosophers of all ages. Of his miraculous precision and accuracy in working we are not called upon to speak, but in his investigation of electrical capacity of a long cylinder his experimental results agree with those worked out mathematically by Prof. Maxwell within a mere fraction, which in one case amounts to only 0·006—.

So much for Henry Cavendish as regards his own individuality. In his intercourse with the very small world in which he moved he was still more eccentric. Friends and intimates he had none; his acquaintances were few and far between, and even they seem to have consisted only of a small sprinkling of the Fellows of the Royal Society whom he could hardly help associating with. He was elected a Fellow of the Royal Society in 1760, and knowing what we do of his habits, it seems surprising that he should have ever been able to summon up sufficient courage to go through the ordeal of proposal and election. He was now, of necessity, thrown much into contact with Sir Joseph Banks, who was then President of that learned Society, and he appears to have been more inclined to associate with him than with any of his other illustrious companions. He even seems to have forced himself into attending the presidential gatherings at Sir Joseph's house in the then fashionable quarter of Soho Square. Such a concession to gregariousness in this most ungregarious of human beings, as he is justly

called by one who knew him, must have been a sore trial to him; but he, no doubt, consented to undergo it knowing well that he could not carry on his own researches without being acquainted with what some, at least, of the more eminent of his fellow workers were doing. Hence his visits to Crane Court and Soho Square, and to the Royal Society Club, which he also seems to have frequented occasionally. He also appears to have been a member of the Cat and Bagpipes Club, which was apparently a kind of Junior Royal Society Club for scientific workers who had not yet earned the privilege of belonging to the more august body.

One of his visits to Soho Square, on the occasion of a larger gathering than usual, is graphically described by one of his contemporaries. *Ex uno disce omnes.* He would drive up to the door in his carriage, watch a favourable opportunity, and glide quickly upstairs as soon as he saw the staircase clear.

Reaching the top of the flight, he would hang his three-cornered hat, of the same fashion as the one his grandfather wore, on his own particular peg, and then lose all heart. He would slink nervously about the passage, making several fruitless attempts to enter the drawing-room. At last he would summon up sufficient courage to turn the handle and creep in. Those who recognised him knew him too well to welcome him in words, or even by looks. He would now steal about awkwardly from group to group until he lighted upon one which was conversing on some of the many topics that interested him. He would listen attentively at a little distance, and occasionally make a remark or ask a question that was always exceedingly to the purpose. If any one answered him without looking at him, he would turn slightly aside and listen attentively; but if he was addressed personally, he would dart quickly away with a low murmur of displeasure and seek some other and more discreet group of speakers. One night an event occurred which he must have viewed in the light of a catastrophe. There was a greater gathering than usual, apparently to do honour to a distinguished Austrian philosopher who was then visiting this country. Taking him somewhat unawares, Dr. Ingenhouz, one of his few acquaintances who could presume to take such a liberty, informed him that his learned foreign brother wished for the honour of a personal introduction to him. Poor Cavendish was completely taken aback for the moment. He seemed to have lost all power of speech and motion. He stared helplessly at the Austrian, who by this time had begun a set speech to the effect that the primary object of

his visit to England was to be presented to the most learned, the most illustrious, the most— But before he could get any further in his adulatory address the object of it had uttered a sharp cry of pain as if he had been wounded, rushed hatless down the stairs and into his carriage, screaming shrilly to his coachman to drive as fast as possible to Montague Place, where he doubtless solaced himself by making a host of perfectly unnecessary measurements.

His appearance, it need hardly be said, was as singular as his manners. He dressed always in the same bygone fashion. Judging by the only portrait of him in existence —taken stealthily and piecemeal on several occasions by one Alexander, the draughtsman of the Barrow Expedition—he bore but few marks of his rank about him. His costume, which he never altered, winter or summer, consisted of a greyish violet, as much stained and faded as poor Goldy's famous peach blossom velvet; black breeches, and untidy-gartered white hose and low shoes, the pinched up face and ungainly figure surmounted by a low-crowned three-cornered hat. He spoke in a thin, reedy voice, tremulous from nervousness, but always with extreme appositeness and great gentleness. He was singularly quick of apprehension, and understood everything at a mere word or glance.

How he schooled himself into attending and speaking at the Royal Society meetings is a puzzle to every one acquainted with his singular shyness. Sir Joseph Banks often shielded him from intrusion by warning all strangers of his peculiarity. The only way of entering into conversation with him was to speak with an averted face, as if some one else was being addressed. He would then converse freely; but as soon as he was in any way taken notice of, he would dart off like a startled fawn.

With all his eccentric ways he was so coldly gentle and kind that his contemporaries tell us that he was not merely looked up to and honoured by his brethren of the Royal Society, but actually loved by many of them. There was nothing of the surly misanthrope about him, and several of his acts seem to indicate that somewhere about his anatomy there was sometimes flowing a tiny warm rivulet of love of his kind. If asked to subscribe to any charity he would look down the list for the largest donation, and immediately sign a cheque for the amount. During his lifetime he gave his splendid library for the use of the public, taking out the books he wanted, and signing a receipt for them. His darling apparatus was also at the service of any deserving student; and on one occasion, when his curator was driven

to the verge of madness by a student breaking a piece of Cavendish's most treasured apparatus, the only rebuke that this gentle solitary could utter was to the effect that young students could only learn to use delicate apparatus by breaking it—a story which is surely to the full as pretty as that of Newton and his little dog Diamond. On another occasion he was told that a once prosperous acquaintance had fallen into poverty. It was suggested to him that a small annuity might at any rate keep the wolf from the poor man's door. Cavendish answered the appeal by tremulously asking if ten thousand pounds would be sufficient.

It has also been said that he was a misogynist, because he always communicated with his housekeeper in writing, and immediately dismissed any female servant who allowed herself to be met by him in his Clapham house. These stories of him, however, are at best nothing but Clapham gossip, collected some years after his death. On one occasion this gentle, timid, feeble old man valorously defended and ultimately rescued a lady from the attack of an infuriated cow,—so at any rate one member of the fair sex could say he was no misogynist. At the christening of a young relation he was told that it was usual to make a present to the baby's nurse; he obeyed the admonition by giving her an uncounted handful of guineas. That he scrupulously avoided all communication with the female sex is undoubted, but he shunned the highest worth and intellect of his time in the same way. Had there been a Mrs. Somerville in his day, and she could have given him any information on any of the multifarious subjects in which he took an interest, it is only too probable that he would not have shunned her.

Very few visitors were admitted to Montague Place. One of the favoured few reports that the rooms were all apparatus. Fewer still were admitted to the Clapham house, where they were always regaled off the same dish,—a leg of mutton, or, if they exceeded a certain number, two legs of mutton. Who can say whether the cold philosopher may not have sometimes warmed into the genial host at these symposia, at which one bowl of punch at least must have been produced in accordance with the custom of the day? We are told that at the Royal Society dinners Cavendish was as cold and reserved as elsewhere; but is it not possible that he may have unbent somewhat at those mysterious Cat and Bagpipes feasts to which he must have gone of his own free will and choice?

His death was like his life—solitary. When he found his end approaching he called his servant, and strictly com-

manded him to leave him alone until the great event had occurred, and not until then to carry the intelligence to his cousin and heir, Lord George Cavendish.

In presence of the reverence and affection with which he was regarded by his fellow philosophers, he could not be said to have died unwept; he has certainly not died unsung. His deeds will live as long as Science itself.

IV. ENGLISH AND AMERICAN PHYSIQUE.*

By GEORGE M. BEARD, M.D.

I.

AMERICA is England in a minor key. All that is good, all that is evil in the United States of the past, or near present, comes directly from Great Britain—the daughter is but a mild type of the mother. In the angry and inexpert discussions of national characteristics, it is forgotten that the difference between one country and the other is far less than is suggested or commonly credited. In criticising England for her failures, her weaknesses, her inconsistencies, her preference for the near to the remote, and the practical to the ideal, we are but criticising ourselves, who derive all these traits by direct inevitable transmission from our maternal home.

Even American buncombe is all English: at public banquets, at gatherings of quiet and sober men of science in that empire, I have heard more of self-exaltation, of reciprocal flattery, of glorification, of hosannas over the greatness of themselves, than one should hear in this country at a rustic Fourth-of-July carousal; indeed, we are outgrowing that academic play, which the conservatism of the mother land holds to as with bands of iron.

The delusion that the two nations utterly differ in kind appears in England as well as in America. This summer the distinguished London physician, Dr. Richardson, gave me an excellent example. The Doctor, in a lecture before a large audience of working men, quoted a passage from my work on longevity of brain-workers, in which a contrast was

* Communicated by the author, having appeared also in "The North American Review."

made between the environment of the muscle-worker and brain-worker. At the close of the lecture, he was told that if that passage—written by an American—were true, they did not wish to emigrate to America, as many of them had thought of doing.

The laws of nature are not reversed by crossing the Atlantic, or by changing the form of government. Forgetting that the purely practical man can never be a first-class man, Americans are wont to call themselves the practical nation, with an implied criticism on all nations that encourage thought; but all our practicality is English: Yankee ingenuity is simply an importation, and the almighty dollar is sired by the divine guinea. The question, Will it pay? was asked in England before this country was born—the problems of abstract right and truth and justice being turned over to German specialists.

The beliefs, disbeliefs, and unbeliefs of men, the true, the false, and the doubtful, England turns to use; she allows no waste threads, but weaves everything into the pattern of the state; to her, sciences, delusions, religions, are all one; she melts them together and moulds them into cathedrals, railroads, bishops, nobilities, civil liberty, livings, benefices, universities, dignity, solidity, comfort; she travels everywhere and forages in all nations for materials to strengthen and adorn the empire; the blunders of other people become her possession; pioneering, experimenting where great risks to philosophy are involved, she leaves to others, and profits by the results. In this feature we, in a certain way, have followed her example.

With these general resemblances there are phenomenal differences of *physique* and character that are of special interest to students of the nervous system.

American v. *English Female Beauty.*

While the beauty of the English girl may endure longer than that of her American sister, yet American beauty has this sovereign advantage—that it best bears close observation. The English beauty appears best at a distance, and grows homely as we approach her: the typical American beauty appears more attractive near at hand; in her case, nearness brings enchantment. The American face bears the microscope mainly by reason of its delicacy, fineness, and mobility of expression—qualities that are only appreciated on nearness of inspection. The ruddiness or freshness, the health-suggesting and health-sustaining face of the English girl seem

incomparable when partially veiled, or when a few rods away; but as she comes nearer, these excelling characteristics retreat behind the irregularities of the skin, the thickness of the lips, the size of the nose; and the observer is mildly stunned by the disappointment at not finding the nimble and automatic play of emotion in the eyes and features without which female beauty must always fall below the line of supreme authority. The English beauties of national and international fame, at whose feet the empire of Great Britain is now kneeling, are of the American type, and in this country they would be held simply as of average rather than exceptional excellence.

It is no hard task for one travelling in Great Britain or on the Continent to distinguish American ladies from those of any other nationality; the practised observer would make a mistake but rarely. At the great watering-places, as Homburg and Baden-Baden, in the lines where travel is thickest, as on the Rhine and through Switzerland, we may often see a face which, far away, seems to be purely American, but which, as we gain a closer view, is found to be all English; should there be a doubt, the voice—the speaking of a single word—often solves the problem.

Riding, once, from Paris to Calais, there stepped into the coach a lady whom for various reasons I assumed to be English, although her whole appearance—her voice, her conversation—were completely American. I concluded that at last I had found a case where it was impossible to make a differential diagnosis between an American and an Englishwoman; and I very soon found that my reasons for believing her English were not well founded—that she was an American, and a typical American, in her voice, face, expression, gait, and bearing, and even in the functional nervous disease from which she had long suffered.

It were well if these two extremes could be united; an American beauty slowly approaching, an English beauty slowly vanishing, present together a picture of human beauty the fairest that could fall on mortal vision. An American lady who unites the American qualities of intellect, of manners, and of *physique*, and who at one period lived for years in English territory, compresses it all in one sentence: "The English face is moulded, the American is chiselled."

The superior fineness and delicacy of organisation of the American woman, as compared with the women of Great Britain, Germany, and Switzerland, is shown in every organ and function—revealing itself in the play of the eyes, in the voice, in the response of the facial muscles, in gait, and

dress, and gesture. The European woman steps with a firmer tread than the American, and with not so much lightness, pliancy, and grace. In a multitude, where both nations are represented, this difference is impressive. In the hourly operation of shaking hands one can tell, in some cases, the American woman of the higher order from a European, Swiss, or German in the same rank. The grasp of the European woman is firmer and harder, as though on account of greater strength and firmness of muscle. In the touch of the hand of the American woman there are a nicety and tenderness that the Englishwoman destroys by the force of the impact. It is probable that the interesting and remarkable feat of muscle-reading, popularly called "mind-reading," would not be so skilfully and successfully performed by English as by American ladies, for the reason that the Americans are physically more delicate and nimble, and their susceptibility to external impressions far greater. This delusion of "mind-reading" was born in this country, and within the past few years. It may be rationally claimed that it could not have originated, or at least have attained so wide popularity in England, Germany, or Switzerland, since not enough could be found there who were capable of performing it to the amusement and astonishment of large audiences.

The voice of the American woman is on a higher key than that of the Englishwoman; and the partially deaf can hear it more easily.

The attractiveness of American women would appear to be the direct effect of climatic conditions, since beauty of the most precious sort requires fineness of organization, delicacy of features, nimbleness and sprightliness of expression. The same influence that makes the American female more handsome also causes her beauty to decay earlier than in Europe. The Englishwoman is less beautiful, less delicate and attractive between fifteen and twenty-five, yet she retains her beauty longer. Women, like plants, need abundant moisture, else they wither. The rains, the clouds, and the storms that enrobe castles and cathedrals in ivy, and keep the meadows green throughout the year, bring freshness and colour to the face; so the English matron of forty-five or fifty is, perhaps, sometimes handsomer as well as healthier than at fifteen and twenty.

The Character of Woman as revealed by Dress.

The dress is the woman: all of female character is in the clothes for him who can read their language.

A psychologist of much acuteness once asked me: "Why are bright colours beautiful in the sky, but out of taste in dress? Why should it be a sign of coarse taste to dress in the most brilliant colours, when all go to see an imposing sunset?"

The answer is, that high culture and sensitive nerves react to slight irritation: while low culture and insensitive nerves require strong irritation. Loudness of dress is, therefore, justly regarded as proof of coarseness of nerve-fibre. The American girl is exquisitely susceptible, is impressed by mild irritation acting upon any of the senses. She dresses in taste, and, where the means are at hand, with elegance, in colours that are quiet and subdued, and noticeable only at a short distance. If we could clothe ourselves in sunsets; if all this resplendency of crimson and scarlet and gold, and all these varieties of hue and form, could descend upon the delicate maiden, and fall about her in palpitating folds like a rich garment, the eye of that maiden and of those who gazed upon her would soon weary; the irritation of such splendour would become a pang, and only be worn as a badge and sign of a nature in the lower stages of evolution. Bright colours—scarlet and red, so common in Switzerland and in certain parts of Germany—are never seen in America in any class; and, among men, the custom of wearing gorgeous and jewelled apparel in public assemblies, as at courts or on occasions of state, is a survival of the barbarian period through which all Europe has passed.

The physiological problem, whether the surface of the eye-ball, independent of the muscles that cover and surround it, can express emotion, a near study of the American girl seems to answer quite in the affirmative. The time that nerve-force takes in traversing the fibres from centre to extremity is now mathematically measured, and it is known to vary with the individual, the temperament, and the season; with race, and climate, and sex, it must also vary. In the brain of the American girl thoughts travel by express, in that of her European sister by accommodation.

America, if archæology is to be trusted, is a modern Etruria, the delicate features and fine forms of prehistoric

Italy emerging from the entombment of ages and reappearing in a higher evolution in the Western Hemisphere.

Certain Nervous Diseases peculiar to America.

A new crop of diseases has sprung up in America, of which Great Britain until lately knew nothing, or but little. A class of functional diseases of the nervous system, now beginning to be known everywhere in civilisation, seem to have first taken root under an American sky, whence their seed is being distributed through the world. A fleet of Great Easterns might be filled with hay-fever sufferers alone; and not Great Britain, nor all Europe, nor all the world, could assemble so large an army of sufferers from this distinguished malady; while our cases of nervous exhaustion would make a standing army as large as that of Russia. Of all the facts of modern sociology, this rise and growth of functional nervous disease in the northern part of America is one of the most stupendous, complex, and suggestive; to solve it in all its interlacings, to unfold its marvellous phenomena and trace them back to their sources and forward to their future developments, is to solve the problem of sociology itself.

A thousand causes have been assigned the task of accounting for this. Among the chief of these accredited causes are fast and excessive eating. Although the Americans are fast eaters, or used to be a quarter or half a century ago, yet in the quantity both of food and drinking they are surpassed both by the English and Germans. Europeans eat oftener than Americans, and eat more, in some cases having four or five meals a day, where the American has but two or three; and consume not only more alcoholic liquors of all kinds, but more fluids of every kind.

The American of the higher class, and these remarks refer only to that class, uses but little fluid of any kind. The enormous quantity of alcoholic liquors, including beer, used in the United States, is used to a large extent by Germans and Irish, and those who live in the distant West and South. There are thousands of Americans who from year to year drink no tea or coffee, and but very little water.

Long since I have surrendered the custom of asking my nervous patients whether they drink coffee, for most of them have been forced to drop the pleasant habit long before they consult me. Through all the Northern States the brain-working classes find coffee in some respects more poisonous than whisky or tobacco, and thousands are made wakeful

by even a mild cup of tea. The incapacity for bearing the gentlest wines and beers is for thousands of our youth the only salvation against the demon inebriety. Thus the united forces of climate and civilisation are pressing us back from one stimulant to another, until, like babes, we find no safe retreat save in chocolate and milk and water. In the South, for climatic reasons, these substances are far better endured than in the North; but the very day on which this page is composed I am called to see a Southerner transiently paralysed, to all appearance, through tobacco alone. Tolerance of stimulants is a measure of nerve; the English are men of more bottle-power than the Americans. To see how an Englishman can drink is alone worthy the ocean-voyage. On the steamer a prominent clergyman of the Established Church sat down beside me, poured out half a tumblerful of whiskey, added some water, and drank it almost at one swallow. He was an old gentleman, sturdy, vigorous, energetic, whose health was an object of comment and envy. I said to him: "How can you stand that? In America, men of your class can not drink that way." He replied, "I have done it all my life, and I am not aware that I was ever injured by it."

A number of years since I was present in Liverpool at an ecclesiastical gathering composed of leading members of the Established Church, from the bishops and archbishops through all the gradations; at luncheon alcoholic liquors were served in a quantity that no assembly of any profession in this country could have desired or tolerated.

It is with mental work as with drinking: long hours of brain-toil are better endured in Great Britain than in America; there is less exhaustion from the strain of overwork. This fact is observed by men of letters and scholars, and men in public life. Parliamentary leaders, &c., in England, can do more speaking, more sitting up late at night, as well as more eating and more drinking, than the politicians of America.

It has been said that the strength of a nation is the strength of the thighs rather than of the brain; and an English physician of eminence has observed that the best population of the cities of Great Britain renew their strength from the large-limbed Highlanders of the North, but for whom there would be a constant degeneracy. It would appear, then, that the qualities which are necessary to make a good, strong nation are precisely the qualities which make a good horseman, and that he who can ride well makes a good founder of states. The English as a

people have that balance and harmony of temperament that always breeds well. Large families are commanded by unwritten law, and this little island has become the spawning-ground of empires.

The American speaks more rapidly than the Central European; he makes more muscular movements of the larynx in a minute; in his nervousness he clips words, articulating indistinctly, and allowing his voice to fall at the end of a sentence, sometimes so as to be inaudible. The Englishman speaks more slowly, enunciates more clearly, says fewer words to a minute, and, as is well known, keeps the voice up where an American would let it fall. The American says more than the Englishwoman, is easier and more alert for converse, quicker to seize a delicate irony, more facile to respond to a suggestion, than the English lady in the same walk of life. I believe, also, that the English, Germans, and Swiss cannot hear as many words in a minute as Americans, the auditory nerve and the brain behind it being incapable of receiving and co-ordinating as many sounds in a given time. Hence it is necessary to speak to them with more calmness and clearness, whatever language may be employed.

Relation of American Oratory to Climate.

American oratory is in part the product of American climate. For success in the loftier phases of oratory, fineness of organisation, a touch of the nervous diathesis is essential: the masters in the oratorical art are always nervous: the same susceptibility that makes them eloquent, subtile, and persuasive, causes them to be timid, distrustful, delicate, and sometimes cowardly. We blame Cicero for the pusillanimity of his old age, and for his terror in the presence of death, and praise him for his spirit and force and grace in the presence of audiences, not thinking that the two opposite modes of conduct flowed from a single source. A nature wholly coarse and hard, with no thread or vein of nerve-sensitiveness, must always fail in the higher realms of the oratoric art, just as it must fail in all arts. Jefferson, after acting his Rip Van Winkle for years, even now enters upon the stage at each performance with a certain anxiety lest he fail; and of more than one orator has it been affirmed that he always dreaded to speak. "Give me an army of cowards," said Wellington; "it is the man who turns pale in the face of the enemy that will fight to

the death." This delicacy of organisation, united with Saxon force, makes America a nation of orators.

Differences in Delusions.

The two nations, England and America, differ in their delusions,—our spiritualism, animal magnetism, and clairvoyance having but slight influence in the mother-country. Delusions, like nervous diseases, are not, however, uniformly distributed in this country, but diminish as we go south. On the warm Gulf Coast the desires to solve the problems of life melt quietly away, the superstitions of the northern type being borne out of sight in the overheated atmosphere; the clairvoyants that grow rich in New York, Brooklyn, and Chicago, would starve in Mobile and New Orleans. A medical patient of mine—intelligent, alert, and observing, well fitted to judge, and of large acquaintance in the southern cities—tells me that one of these seers, who came there, returned without securing any native patronage; the little that came to her was from northern visitors.

The swath that Brown the mind-reader cut across this continent—mowing down professors, scholars, philosophers, editors, colleges, and universities by the score, was in a northern section only; had he gone through the Gulf States his path would have been like that of a ship at sea—a slight ripple, in a moment disappearing. Of the large number of names of universities and schools, of teachers of philosophy and of science, that adorn his placards, like the scalps of the red man as he returns from battle, not one is from the South.

EXPLANATORY REPORTS ON NEW SCIENTIFIC PROCESSES AND INVENTIONS.

[These Reports will not partake of the nature of an Advertisement, but will be impartial descriptions, written and signed by well-known Specialists.—Ed. J. S.]

The Thomas and Gilchrist Process for Eliminating Phosphorus in the Manufacture of Steel.

Until recently the puddling of pig-iron was regarded simply as a process of oxidation, and it was not until the practical working of the Bessemer converter revealed the fact that neither sulphur nor phosphorus are effectively removed in it, that the mere oxidation theory was abandoned.

Now we know that puddling does something more, that oxidation alone, though fully effectual in removing silicon and carbon, fails in the elimination of sulphur and phosphorus. It is on this account that special "Bessemer pigs" have to be made from hæmatite or other rich ores nearly free from these impurities. Such are scarce in this country (they amount to only about 12 or 13 per cent of our native ores), while clay ironstones containing much phosphorus are very abundant. Now that mild Bessemer steel is so largely superseding wrought-iron, and the iron-masters of the North have erected huge blast-furnaces in the midst of the impure phosphoric Cleveland ores, very large interests are involved in any effort to render the Cleveland pig available for Bessemer or Siemens-Martin purposes.

The theory of the failure of oxygen in removing phosphorus is not yet fully cleared up, though it has been much discussed. Knowing the extreme readiness with which our old chemical plaything, the stick of phosphorus, unites with oxygen, it was theoretically regarded as the first to be driven off in the course of the vivid combustion of a Bessemer "blow," but such is not the case; the silicon burns freely, the carbon follows, and then the iron itself; while the phosphorus and sulphur remain, as though they were incombustible substances. The probable cause of this anomaly is, that at very high temperatures iron is able to reduce both sulphurous and phosphoric acids, just as carbon at high temperatures reduces the oxides of metals which at lower temperatures have much stronger affinities for oxygen than carbon has. Thus the phosphoric acid may be formed and immediately reduced, and its phosphorus re-combined with the iron as before. But if we can put something else in the way that shall

take up this phosphoric acid immediately it is formed, and thereby produce a compound not decomposable by the hot iron, nor capable of combining with it, the original phosphorus may be separated.

This is the aim of the process of Messrs. Thomas and Gilchrist. Some years ago I propounded a theory of the action of puddling in which the removal of the sulphur and phosphorus was attributed to a washing out by the slag or cinder, but at that time I merely regarded the action as a sort of diffusion by adhesion, like the diffusion of the impurities of dirty clothes in the water of the washing-tub. Following up this analogy, I may say that the Thomas and Gilchrist process consists in what is equivalent to the addition of soda by the laundress; a basic slag is produced which is capable of combining with the phosphoric acid and the sulphurous or sulphuric acid as they wash out, and of forming a phosphate, or a sulphur salt, that the iron cannot combine with or decompose.

This idea of a basic slag is simple enough in theory, but difficult to carry out in practice. The very high temperature of the contents of the Bessemer converter demands a highly refractory lining. The ganisters, &c., commonly used are siliceous,—*i.e.*, acid rather than basic,—and lime, which is cheap, and has the requisite basic character if simply added in the ordinary converter, combines with the silica of the lining, and forms a fusible lime glass, resulting in the destruction of the lining and also of the basic energies of the lime. Soda is still worse, and other bases no better.

Such was the early difficulty encountered by these inventors. What then must be done? The natural answer to this is, that a new lining be found, either basic in itself or allowing the addition of basic material with the charge. As all linings are more or less attacked, and go to supply material for the slag or cinder, the first is the better device, and accordingly the production of a lining that is at the same time basic and refractory has been the object of a long struggle, following the first experiments which satisfied Mr. Thomas that a basic slag is capable of removing the phosphorus.

An account of these experimental struggles would occupy too much space here, and therefore only the final result may be described, which is that Bessemer converters, or the hearths of Siemens-Martin furnaces, are lined with specially made basic bricks, composed of alumino-siliceous magnesian limestone burnt at a very intense white-heat. The best composition of these bricks is found to be 87 to 91 per cent carbonates of lime and magnesia; 3·5 to 6·5 per cent alumina; and 3 to 6·5 per cent of oxide of iron. The presence of not less than 30 per cent of carbonate of magnesia in the raw material is found of great service in preventing the subseqnent disintegration of the burnt bricks by the action of moisture, and also in giving them a highly

dense and tough structure. They shrink nearly 50 per cent of their bulk in burning, and thus acquire great density and hardness.

The results have varied with the progress of the experiments conducted for the purpose of battling with the difficulties as they presented themselves. The following are the latest, as stated in a letter I have just received from Mr. Thomas:—

1. "That phosphorus replaces silicon as a heat-giving element with perfect success; thus we have blown at least a thousand tons with under 1 per cent silicon, and much prefer it. We have often much under 0·5 per cent."

In explanation of this I may add that it has hitherto been found desirable to use for Bessemer purposes pig-iron containing exceptionally large proportions of silicon or carbon, or both.

2. "That up to 3 per cent phosphorus can be reduced to 0·05 per cent (if the silicon is low) with regularity."
3. "That when sulphur in pig is over 0·2 per cent, *at least* 50 per cent is eliminated, often 75 per cent. When under 0·1 per cent there seems a difficulty, at present, in reducing to under 0·05 with regularity, though we often remove 80 per cent."
4. "That the phosphorus is removed as phosphate of lime."
5. "That the combustion of phosphorus provides not only sufficient heat to keep the bath liquid, but enough to keep the slag (formed by the 10 to 20 per cent addition of lime) also quite fluid. This slag contains—

Lime and magnesia	...	50 to 65 per cent.
Phosphoric acid ...	...	10 to 16 ,,
Silicic acid ...	... ...	6 to 16 ,,

The rest oxides of iron and manganese."

6. "We shall be able to run the vessels hard without material repairs for at least a week."
7. "That the bricks can be produced regularly and easily, attention being had to the composition (the burnt brick should contain about 80 to 85 per cent of magnesia and lime, and 15 to 20 of alumina, silica, and oxide of iron), and the firing at a heat much superior to that even for silica bricks."

Mr. Thomas estimates the cost of lining at not more than 1s. 6d. to 2s. per ton of steel "at worst."

I venture to suggest that there still remains open an apparently unexplored field for the application of this process, viz., the production of high quality tool steel from the best hæmatite pigs, as well as producing common rail steel from Cleveland pigs, by the Bessemer process, instead of the costly cementation of Swedish charcoal iron, and its subsequent fusion in crucibles. I am fully aware of the great difficulty of this problem, owing to the stubbornness with which the last traces of phosphorus and sulphur adhere. (2.)

If the basic lining can reduce the phosphorus of average hæmatite pigs as low as that occasionally existing in exceptionally pure samples, fine tool steel may be made in the Bessemer converter. I make this assertion on the practical results obtained about ten years ago, at the Atlas Works, Sheffield, by the late George Brown and myself. I analysed the deliveries of Bessemer pigs, and selected one sample of "Cleator" containing only a trace of phosphorus, and otherwise excellent. With this G. Brown made steel capable of taking 1½ per cent of carbon, and fairly comparable with "pot steel" made from Swedish charcoal iron.

The importance of this at the present moment is almost incalculable as regards the future of our national steel industry. The temptation to use crop ends of rails and other Bessemer scrap for cutlery and tool-making is now so great that vast quantities are used, and the character of British manufactures is seriously injured. If steel as above described could be freely made as I now suggest, its cost would not exceed that of ordinary rail steel by more than a farthing per pound, which surely would be too little to tempt the meanest of unscrupulous manufacturers.

In conclusion I may add that there is a possibility of development in the opposite direction, viz., that of selecting by preference for ordinary purposes, pig-iron excessively rich in phosphorus, in order to obtain the heat from its combustion in the converter, and also a slag of phosphate of lime rich enough to be used as an artificial manure. (3.)*

W. Mattieu Williams.

Profersor Barff's Process for Preventing the Corrosion of Iron.

The most useful of all the metals has an exceptional predisposition to corrosive oxidation,—so exceptional that its durability may be, to a considerable extent, increased by coating it with a thin film of a metal electro-positive to itself. The zinc which covers "galvanised" iron has a stronger affinity for oxygen than the iron which it protects from oxidation.

The source of this anomaly resides in the peculiar chemical and physical constitution of the respective oxides of these two metals. When zinc is exposed to air it combines superficially with an equivalent of oxygen, and then has done with it. This

* Since the above has been in type I learn that this is being done in Germany, and that Mr. Thomas believes that he has perfected a system of turning the slags into a valuable commodity by isolating the phosphate of lime.

film holds the full dose that the metal can obtain by such exposure, and forms a compact continuous varnish, protecting the metal below from further oxidation. Copper and its alloys oxidise in a similar manner, and lead protects itself still more effectually by ultimately obtaining a varnishing film of sulphide. Iron behaves very differently. It is capable of forming a series of oxides, and some of these oxides combine with each other as acid with base, besides which the higher oxides may act as oxygen carriers for the oxidation of the metal or the further oxidation of its lower oxides.

The through rusting of iron depends on these actions:— Exposed to air and moisture the protoxide, or as some affirm the protocarbonate, is first formed; this rapidly passes on to the hydrated sesquioxide, or well-known red rust. This red compound, besides being a feeble acid, readily gives up some of its oxygen to bodies capable of taking it, and thus a coat of iron rust, instead of protecting the metal below, as in the case of the oxide films of zinc, bronze, &c., has the opposite effect of acting as oxygen carrier. Dr. Miller says that when rusting has begun "moisture is absorbed from the air by the oxide, and thus a species of voltaic action is produced, the oxide performing the part of an electro-negative element, whilst the iron becomes electro-positive and the atmospheric moisture acts as the exciting liquid." Certain it is that, once started, the rusting of iron proceeds inwards, and but limited success has attended the efforts hitherto made to prevent it.

In this, as in so many other instances, the study of natural phenomena might have solved the problem, for there is a natural compound that is not at all addicted to rusting, even under circumstances of the severest exposure. This is the "loadstone" or magnetic oxide of iron of composition intermediate between the protoxide and sesquioxide, and by some regarded as a compound of protoxide and sesquioxide. I have now before me a sample of the ironsand of Taranaki (New Zealand) which, if I am rightly informed, is collected on the sea-shore. It is composed of grains of this black oxide that are separable by the magnet from the associated siliceous grains. The most careful examination reveals no indication of rusting on any of these, in spite of the excessively severe test to which they have been subjected for ages.

Prof. Barff's process consists in forming this oxide upon the surface of manufactured iron articles. Its mere production is easy enough: the essential element of the practical problem is to obtain it as an adherent and perfectly continuous coating, for if it is perforated by the smallest pin-holes, communicating with the metal below, further oxidation will commence at these openings, and the resulting rust will presently undermine the protective coating and spread itself around.

A film of magnetic oxide may be formed by merely heating iron in air; ordinary iron scale is a rude example of this.

Prof. Barff's method is to subject the manufactured article to the action of superheated steam in a sort of oven chamber or muffle; and he states that one of the conditions of success is that the steam shall be perfectly dry, and another that atmospheric air be excluded. In his earlier experiments it was often found that the black oxide scaled off wrought-iron articles, and this is attributed to an insufficient and irregular supply of steam allowing admittance of air. The presence of moisture is prevented by completely superheating the steam, which is raised to a temperature of about 900° F. for wrought-iron and steel, and from 1000° to 1500° for cast-iron. After describing a long struggle with the difficulties which presented themselves subsequently to obtaining the original patent, Professor Barff told the Society of Arts, on the 26th of March last, that these laborious and costly experiments "have resulted in my being able to state that my process is now commercially perfect, and is waiting the enterprise of gentlemen in the iron trade to take it up and use it." From the prospectus of The Rustless and General Iron Company it appears that this has been done.

The properties of the artificial surface of magnetic oxide which is thus obtained are—

1. The durability of a stable compound not liable to oxidation, nor to the action of ordinary corrosive agents. Prof. Barff has published a number of testimonials from manufacturers and others, who have tested the coating very severely by exposure to weather, to sea water, to alternations of temperature, as in cooking-vessels, &c.

2. The appearance is agreeable, and has the metallic character of iron, but of darker colour. It is totally different from any paint.

3. It gives great hardness. Prof. Barff states that when one-sixteenth of an inch thick or less "an ordinary flat rasp will not remove it without great labour; it resists emery powder.

4. "Substances which adhere to iron, zinc, and enamel will not adhere to it. Saucepans in which arrowroot and other sticky substances are cooked can be cleaned with the greatest ease, after they have been oxidised, a simple wipe removing all dirt." Water was "evaporated in an oxidised pan for six weeks—common tap water; the deposit found was removed with a duster; it did not stick to the iron."

5. "Articles coated can be submitted to a high temperature, even a red-heat, without the coating being injured or disturbed."

6. "The process tightens the rivets, and assists in caulking rivetted iron plates."

It is not applicable to wire or thin plates that have to be bent after treatment, as the coating chips off when bent to a sharp curve.

The above account of the success of the process is based on the statements of the inventor and the testimonials he has received, in reference to which I may add that Prof. Barff, in his published accounts, has candidly admitted the failures of his first attempts and the defects of early specimens, the remedying of which has been achieved by eighteen months' exclusive devotion to experimental investigation of their causes and the means of remedying them.

W. MATTIEU WILLIAMS.

ON WATER AND AIR.*

By JOHN TYNDALL, D.C.L., LL.D., F.R.S.,

Professor of Natural Philosophy at the Royal Institution of Great Britain.

LECTURE I.

FIFTY-TWO years ago, commencing on a day in the year 1827, Mr. Faraday gave the first course of juvenile lectures in this place, and the lectures have been continued every Christmas without interruption from that time to the present. For years before his death, when he had given up all other engagements, it was his habit to lecture every year to boys and girls at Christmas, for he thought it a most important thing that they should not grow up in the midst of this wonderful system of Nature in which we dwell without knowing something about it. There cannot, I think, be a doubt that a great deal of the interest that is now taken in the scientific education of the young may be traced back to those juvenile lectures which Faraday delivered in this room.

A knowledge of the phenomena and laws of Nature is sometimes called "natural knowledge." The Royal Society, for instance, which was founded 220 years ago, announced its object to be "the improvement of natural knowledge;" and I trust that we who are here assembled together in the Royal Institution, which was founded 80 years ago, will, for the next fortnight, work cheerfully together in the great field in which natural knowledge is to be gained.

I have chosen for this course of lectures two of our most familiar substances—Water and Air. Water is a very common article of diet. If you take a man weighing 11 stone, and weigh the muscles of that man separately from the bones, they will weigh about 64 pounds; but if you dried those muscles, so as to convert them into a dry mass, they

* Being a Course of Six Lectures adapted to a Juvenile Auditory, delivered at the Royal Institution of Great Britain, Christmas, 1879. Specially reported for "The Journal of Science."

would be reduced in weight to 15 pounds, so that, out of the 64 pounds, nearly 50 pounds are pure water. Hence I think you will agree with me that I am not wrong in stating that water is a very important article of food. Every mutton chop and every beefsteak that we consume contains water in this proportion.

But we not only thus feed upon water, but we drink it directly. Whence comes our drinking water? Well, any thoughtful boy or girl here present who had time to think would say that, eventually, it comes from the clouds. How does it get there? That question can be answered thoroughly by-and-bye. At the present time we know, or at all events we assume, that the water comes first of all from the clouds. If you trace the course of the Thames backwards, you find that the very broad river that we have here in London is joined by other rivers right and left, until, finally, you come to the Cotswold Hills, where you find that what is here the Thames comes down to a small rivulet. This rivulet is joined by other rivulets on the right and left as you go down it, and then, at last, the river assumes the breadth at which we have it here when it reaches London. Now, this water which comes from the Cotswold Hills falls on those hills as rain. But not only does the water flow thus over the surface of the collecting valleys, and then flow to the sea in the form of rivers, but it in part sinks into the ground and percolates through the soil, and here and there appears as a pellucid spring. That is the origin of spring-water. It comes originally from the clouds, but it has percolated through the earth and come out somewhere, and there we have our clear spring.

Now, the hardest rocks are more or less soluble in water. You know that sugar and salt are very soluble; but rocks are also more or less soluble in water, so that all our river-water and spring-water has more or less of mineral matter dissolved in it, as sugar is dissolved in a cup of tea. Well, how do we know this? A great portion of the mineral matter may be removed from the water merely by boiling, and it is so removed in all our utensils which are employed in the kitchen. Just before the lecture I went into our own kitchen upstairs, and I looked into this kettle, and I found a thick mineral incrustation. I dare say that I can get this very hard substance out of the interior, and if you look at the interior surface of that kettle after the lecture, you will see that it is covered by this very thick crust, which is so very hard that I can hardly get it to break away. Here it is. There is a crust of this thickness on the interior surface

of the kettle, and this is due to the hardness (as we call it) of the water. By boiling, a great amount of the mineral matter is precipitated and is rendered solid, and it settles upon the interior surface of the kettle, and produces that incrustation to which I have referred. Here is a copper tube which belonged long ago to a boiler at the Athenæum Club; and if, after the lecture, you come forward and examine this tube, you will find it coated so that it is almost choked up with a series of beautiful concentric incrustations of the solid matter which was contained in the tap-water supplied to the Athenæum Club and which was deposited upon the interior surface of the tube.

Not only will boiling liberate and re-solidify dissolved matter, but evaporation does the same. If you go to St. Govor's Well, in Kensington Gardens, and look at where the water drips or splashes down from the little outlet, you will see a red mark where it falls. That is oxide of iron, and if you taste the water you will find that it has an inky taste. As the water splashes down, it is in part evaporated, and the iron is liberated there in the form of this oxide of iron. The reason why caverns are usually found in limestone strata is that limestone is more soluble in water than most other rocks; and if you wander, as I have done, in limestone caves, you will usually find in each cave a stream of water which has washed out the limestone and produced the cavern; and sometimes you see from the roofs of those caverns—I was going to say most beautiful icicles—but stalactites hanging down. These are due to the water which has entered into the fissures in the roof above, and percolated through the roof and dissolved some of the limestone, and made its way into the cavern, where the water is in part evaporated; and, in consequence of the evaporation, the solid matter has been deposited, and you find that, as it evaporates, these beautiful stalactites grow longer and longer from the roof towards the floor. Then drops of water fall from the end of the stalactites upon the floor, and there the water is still further evaporated, and a heap is produced called a stalagmite; and. as the water continues to drip, more and more of the solid matter is deposited below, so that the stalagmite grows from below upwards, while the stalactite grows from above downwards, and by-and-bye they meet in the centre, midway, with the point of the stalactite actually in the centre of the stalagmite, and most wonderful and fantastic pillars are thus produced. If you visit any of the great limestone caves you will see examples of this kind. Here are some stalactites from

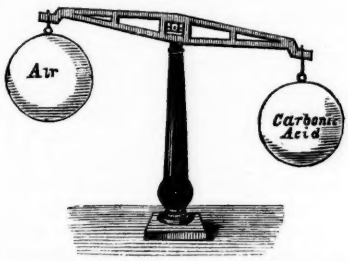
St. Michael's Cave at Gibraltar. They are so beautiful that it seems a kind of desecration to break them. Here we have beautiful stalactites produced by the evaporation of water containing a mineral in solution, and that mineral is what we call carbonate of lime.

And now we have to examine something about this carbonate of lime. It is a body compounded of carbonic acid and lime. Every boy knows what lime is. I have here some quick-lime in this vessel. In order to show the influence of boiling, I have here water boiling in two different flasks. One of them has, perhaps, been boiling an insufficient length of time to deposit all its solid matter, but I think you will see that there is a very considerable difference between these two flasks. Now, these are two different kinds of water. One of the flasks contains water for which I am indebted to a distinguished engineer, Mr. Homersham, who has made certain water-works at Canterbury. It is the Canterbury water, which has been softened by a process that we shall learn about by-and-bye. You see that the water in this flask is perfectly clear, because all the mineral matter has been removed from it before boiling; but the water in the other flask, which is the tap-water of our house, is thick and turbid. You see that the mineral matter has been let loose, and is forming a kind of mud, in point of fact. If I place the flask in this beam of light those at the right and the left will see that sparkling stuff, which is the mineral matter—the carbonate of lime—which has been liberated by the boiling; and it is this stuff which, when deposited upon the interior surface of our kettle, produces that incrustation to which I have referred. This open vessel merely shows the effect of evaporation. A quantity of water from St. Govor's Well in Kensington Gardens was placed in this basin this morning and evaporated, and there is the substance which gives the water its peculiar taste and its peculiar medical value. This is the substance which, when it is liberated by evaporation, produces that red splash which you see when you look at the well.

Now, we want fully to understand the meaning of this phrase that I have used—carbonate of lime. Carbonate of lime is, as I have said, a mixture of two distinct substances —carbonic acid gas, and lime. I will just remind you of what this carbonic acid is. There is a quantity of it here. My friend, Professor Dewar, is kind enough to help me, and here he has been exhausting a glass globe, and here is another exhausted globe. At the present time the two globes balance each other. Now, if I allow carbonic acid to enter

one globe and air to enter the other, you will find that the globe into which the carbonic acid enters will sink down. (Fig. 1.) Why is that? Because the carbonic acid is heavier than

FIG. 1.



the air; and it is so heavy that if you put it into a vessel it will lie at the bottom. Here is a vessel which is now full of it, and if Mr. Cottrell gives me a match I will see whether the gas is not there; for, as many of you no doubt are aware, it is a peculiarity of this gas that it will not support a flame. You see that the flame goes out very soon when I dip it into the gas.

Now, in order to show the weight of the gas, I will blow a soap-bubble, and throw the soap-bubble into this invisible gas. The gas is there at the present time like a liquid; and, although nobody can see it, I think you will find that when I blow the bubble and throw it into the gas, the gas will be sufficiently heavy to support the weight of the bubble. [The lecturer blew a soap-bubble from a thistle-headed glass tube, and allowed the bubble to fall into a large glass vessel of carbonic acid gas. The bubble floated about midway down the vessel.] You see that it does not sink.

Well, now, in order to show you again the heaviness of this gas, I will pour it out before you, although, as it stands there, it is perfectly invisible. I want you to have a perfectly distinct idea about it. [The vessel in which the soap-bubble had been floating was then tipped up in front of the electric light, so that its shadow was received on a white screen. The carbonic acid streamed gently downwards from the lip of the vessel and cast a shadow upon the screen.] There you see the gas falling, although it is perfectly invisible under ordinary circumstances. This heavy gas falls down before you like a liquid.

This, then, is one of the constituents of our carbonate of lime. The other constituent is this ordinary lime. If you

mix this lime with water, the water dissolves a certain amount of lime, and then we have lime-water; and here, thanks to Mr. Homersham, I have a specimen of lime-water which is obtained from the Canterbury works in a way which I will presently describe to you. Lime-water is produced, as I have said, by a solution of ordinary lime in water. Lime is not very soluble. It requires about 70 gallons of water to dissolve a single pound of lime. But here we have our lime-water; and if you were to taste this solution you would find it very pungent to the taste, because of the lime which is dissolved in it. Now, I wish to make carbonate of lime in your presence, and I will take this beaker, as it is called, and I will pour a portion of this lime-water into the beaker. There it is. Mr. Cottrell has here an apparatus for making this substance which we call carbonic acid—that heavy gas which was poured out a moment ago in your presence. I intend to let the carbonic acid bubble through the lime water. You see, I am going to the A B C of the question, and I want to bring you from the A B C as far up as we can climb. But at first I am going to the elements of the question, and those who honour these lectures with their presence will, of course, remember that the lectures are addressed to boys and girls, and that learning or depth would be very much out of place here.

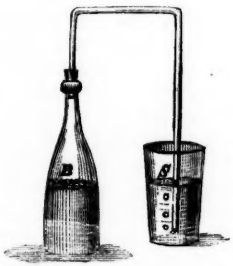
Now, I have the carbonic acid in this vessel, and I will bring it into contact with the lime-water. You will then find that that clear liquid will become milky. Mr. Cottrell will allow the gas to bubble through the water, and you will see in a very short time that the liquid is rendered milky. I have placed this black cloth here [behind the vessel containing the lime-water]. It is one of the devices that we employ in order to make things visible. The change in the appearance of the liquid is due to the formation of this carbonate of lime, which is an insoluble white powder, and which becomes diffused through the water, producing that milkiness which you see before you.

Instead of making the carbonic acid in the way in which it is made there, it may be made by means of marble or chalk, which are themselves carbonates of lime. Carbonate of lime is a compound of lime and carbonic acid; and if you pour upon the marble or chalk an acid which is stronger than the carbonic acid, the carbonic acid will be liberated. Every boy may do this for himself. Here I put a few bits of chalk into this vessel, and if I pour upon them a little acid, you will find that it effervesces. I do this for the

purpose of enabling you to repeat the experiment for yourselves. Here is a small beaker—a small glass, and we will put into it some chalk, and pour upon it a little hydrochloric acid, and, as I have said, we shall have effervescence. There you see the mixture effervescing. Mr. Cottrell will pour into a beaker a quantity of lime-water, and allow the carbonic acid gas to bubble into it. There you see the gas is bubbling through the water, and you will find that the lime-water becomes milky as before.

Here we have a bottle of champagne (B, Fig. 2), and I want to show you that we can make our carbonate of lime from the carbonic acid issuing from champagne. This is a bottle of

FIG. 2.



Mumm's extra dry champagne. I will cut the wire and remove the cork. Here is a cork with a bent glass tube passing through it. We will put it into the bottle. The champagne is not very well up, so we will stir it a little. [The bent tube issuing from the neck of the champagne bottle was held with its farther end in a glass vessel of lime-water (S), so that the gas given off by the champagne might bubble into the solution. In a short time the lime-water became turbid, as in previous experiments.] Here we have got our chalk produced from the carbonic acid of the champagne.

And now I want to show you that carbonic acid is also a gas that we exhale from our lungs. I will take this small vessel and pour a little lime-water into it, and then simply blow into the vessel. We inhale the atmospheric oxygen, and, after this has done its work in the body by burning part of the body, we exhale carbonic acid. Here we shall have the carbonic acid coming from my lungs, which carbonic acid will unite with the lime in that water, and

produce carbonate of lime or chalk in your presence. [The lecturer blew into the lime-water by means of a glass tube.] You see a single inhalation is sufficient to produce this chalk by the carbonic acid from the lungs.

Now I am about to approach a very important point, and that is a point that practically bears upon the question of the solution of minerals in water. This thing which we call carbonate of lime exists in two forms. It exists as a single carbonate, which takes up a certain amount of carbonic acid; and it exists as a double carbonate or bicarbonate, which takes up twice as much carbonic acid. I say that the carbonate of lime exists in two forms—the single carbonate and the bicarbonate; and what you have now to remember is that the single carbonate is almost insoluble in water, and that the bicarbonate is very fairly soluble in water. What is the consequence? The water coming from the clouds has always a certain amount of carbonic acid dissolved in it. When such water falls upon our chalk hills, what occurs? It soaks into the chalk; it percolates through the chalk; it dissolves the chalk; and the chalk so dissolved in the rain-water is present as a bicarbonate of lime. If the carbonate were to remain in the form of single carbonate, the rain-water could hardly dissolve it at all; but, as it is converted by the rain-water into the condition of bicarbonate, the rain-water dissolves a great deal of it. The conversion of the carbonate from the single carbonate to the double carbonate renders it very easily soluble in water. I have here some water from the neighbourhood of Canterbury, where there is a well from which is pumped a million and a half of gallons every day from the body of the chalk. Here is the hard Canterbury water, and I pour a quantity of this hard Canterbury water into the beaker. Now, I say that the lime there is in the soluble form. It is in the form of the double carbonate, or the bicarbonate, which is another expression for the same thing. Now I have here some lime-water. This Canterbury water is beautifully clear and is pleasant to the taste, but you would find it exceedingly difficult to wash in this water. In point of fact, if you operate with soap in this water you find it very difficult to get a lather in it. For a certain time you cannot possibly get a lather. That water contains, I should say, more than 20 grains of carbonate of lime dissolved in every gallon. Where washing operations have to be carried on, on a large scale, with this water, an immense amount of soap is wasted, not to wash, not to cleanse your hands, not to cleanse your linen, but simply, first of all, to

remove the lime from the water before the water can produce a lather, and before the water can be used as a washing medium. Well, now, the question is—How is this to be rendered soft? Or, can this water be rendered soft on a large scale, or in an effectual way? Yes. That question has been answered in a most satisfactory manner by Dr. Clark, of Aberdeen, and he has invented a process for the softening of water, which, I think, is likely to come into great request in the future. At first sight it is a very extraordinary process; for what does Dr. Clark do? He takes the lime from the water by putting more lime into it. Now that appears to be a strange assertion; but give me your attention, and there is not a boy here present that will not understand what I mean by that expression. There [pointing to a vessel of hard water] is the lime in the form of what we call bicarbonate. There [referring to another vessel] is the lime, not united with carbonic acid at all, but as lime-water. Suppose I pour a quantity of that lime-water upon that hard water. There is nothing in Science which is more instructive, or more interesting, or more inspiring, than the power of prevision,—the power of looking in advance,—the power of allowing the mental eye, so to say, to go before the eye of the body. Now let us consider what is likely to occur if I pour this lime water into that hard water. The lime in that lime-water will take away half the carbonic acid from the bicarbonate which is present in the hard Canterbury water. What is the consequence? It will convert the bicarbonate into simple carbonate. What again is the consequence? The simple carbonate, being insoluble in water, will appear as a milky mass in the fluid. I should not be satisfied if every boy did not understand me in this most important process. Here we have the lime-water. By adding this pure lime-water to the hard water we take away half of that carbonic acid which enables the lime to be dissolved. Then we convert the soluble bicarbonate into the insoluble simple carbonate, and down it goes as a milky mass, and the change is shown in your presence in that way. There is the lime which has been separated from the hard water. This is precisely the process used by Mr. Homersham, at Canterbury, and at Caterham and elsewhere. I have gone specially to all those places to see the water softened, and a more beautiful process you could not imagine. Take the case of Canterbury. You go there into a space which is perfectly clean, covered from all contact with the dust or *débris* of the air. You see there three great reservoirs. Each one of these

reservoirs is capable of containing 120,000 gallons of water. You go into a little adjacent, room and you see there a small reservoir, and in it you see a beautifully clear liquid ; but the probability is that in all the reservoirs you will see a beautiful white powder. The small reservoir is used purely for the purpose of making the lime-water. It contains the lime in a very fine state of division, and mixed with water, and therefore called "cream of lime." After being mixed with the water, the lime is allowed to stand, and the solid undissolved lime subsides to the bottom, and you have a beautiful transparent lime-water above. The hard water is pumped from the wells in the chalk, and is then allowed, first of all, to be mixed with a measured quantity of this perfectly transparent lime-water, for the proper quantity is perfectly well known ; and then instantly you have a beautiful fine whitewash produced in the reservoir, something similar, in fact, to this which has been produced in this vessel, and produced precisely in the same way. The mixture of the two transparent liquids produces this whitewash. The mixture is allowed to rest for twelve, or, better still, twenty-four hours. The carbonate of lime which has been liberated sinks slowly to the bottom, leaving a liquid of the most exquisite purity and softness on the top. The carbonate of lime is taken away, and the hard water is in this way converted into soft water. In the bottom you find a powder consisting of carbonate of lime ; and here, thanks to Mr. Homersham, I have some of that beautiful powder. It is as fine as the finest flour. Bakers in general, I believe, are thoroughly honest men, but one would not like this fine powder to fall into the hands of a thoroughly dishonest baker. It is so very like flour that he might materially adulterate his flour by means of this beautiful carbonate of lime. This is the carbonate of lime that has been separated from the chalk water at Canterbury, and deposited at the bottom of the reservoirs.

But now the thought occurs to me, as I am speaking to you, to give you an opportunity of exercising this power of prediction, this power of prevision, of which I have spoken. And here I will take, first of all, a little of the lime-water and mix it with some distilled water. And here is some carbonic acid gas. Now I am going to ask you to turn prophets. When I allow the carbonic acid to enter the mixture of lime-water and distilled water, what you have already observed will occur. We shall have the liquid converted into a milky mass ; but will this be due to the

precipitation of bicarbonate of lime, or to the precipitation of single carbonate of lime? Which? Somebody lisps out "The single carbonate." I wish he had courage enough to say it out. It is the single carbonate; and here is the point which I want you to predict. Suppose I continue to pour a sufficient quantity of carbonic acid into the water: suppose I continue to supply the carbonic acid: what will occur? The single carbonate, having plenty of carbonic acid to take up, will be converted into the bicarbonate, and after having first of all precipitated the single carbonate, we shall convert it into the bicarbonate and re-dissolve it. And that is what I am going to try whether we can do. Here is our liquid, and here it is being rendered milky—very milky indeed—by means of the carbonic acid gas. And now, if you will give me your patience for a time, I am strongly inclined to think that, by the continued addition of the carbonic acid, we shall convert the single carbonate into the bicarbonate, and that that milky liquid will be rendered perfectly transparent by the solution of the single carbonate. Now, this is one of the things which men of science, and which boys learning science, ought to be able to foresee. If our principle be tr ue, then, by the addition of carbonic acid to the milky liquid, we shall convert the carbonate into bicarbonate. [The addition of carbonic acid was continued until the milky-looking liquid became clear.] This is now bicarbonate. If I pour into this liquid some lime-water, I shall rob the bicarbonate of half its carbonic acid, and convert it into the single carbonate. [The experiment indicated was performed.] Here you see what occurs. You have the single carbonate in this insoluble form produced thus before you. Now, it is not for the purpose of amusing you that I bring this before you. It is for the purpose of bringing before your minds the manner of the reasoning of scientific men—the strictness of their logic—the incessant appeal from reason to facts by which they verify what they conceive.

I will now perform a very homely experiment, but still a very useful one. I want to give you some examples of the quality of this Canterbury water. Here are two basins in which I intend to produce a lather if I can. We will place in one of those basins some of the soft Canterbury water, and we will place in the other basin the ordinary tap water of the Royal Institution, and I will wash my hands with your permission in both basins, and then we shall see where the best lather is produced. What you will observe is that, with a very small amount of soap, I shall be able to produce a very good lather in the soft Canterbury water; but I

shall not be able to produce any lather in the hard water of the Royal Institution by the amount of soap that I communicate to it. You will find, perhaps, a little lather—a few bubbles at first, but they will speedily disappear. You will find that upon the soft water a beautiful lather of soap bubbles is formed, and on the other there will be a very greasy mass, which will be due to the combination of a certain acid in the soap with the lime of the water. The acid is called margaric acid, and the curdy mass which is formed is called margarate of lime. Here, from a very small amount of soap, you see a very beautiful lather is produced in a moment in the soft water. A permanent lather covers the bowl of water. I go to the other basin and operate in the same fashion, and I obtain some few soap bubbles at the top, but they will soon disappear ; and I see floating on the top and mixing with the water a quantity of this curdy, unpleasant-looking stuff that I have spoken of as margarate of lime. Now, with a glass tube, I will blow into this lather [that produced from the soft water], and I get a very splendid and permanent heap of bubbles. In the same manner I blow into the basin containing the tap-water, and you see how few bubbles are produced, and their rapid disappearance.

I have now to say a word upon some of the other properties of water, and first we will take its colour. The colour of water is a delicate blue. If you pour water into an ordinary glass you see nothing of the colour of the water, but in large masses you can see the colour, or, at least, the colour can be revealed. For the purpose of showing the colour of water I have here a tube 15 feet long, and that tube is partly filled with water. But before we deal any farther with the colour of water, I should just like to say three or four words with regard to colour in general, and for that purpose I will show you, if I can, on what all colour depends.

I have here in this camera a little artificial sun [referring to the electric lamp]. If we take the light of the sun at noonday on a cloudless day, we call the light which it gives white light. Sometimes, as the sun sinks towards the horizon, his rays become red ; but at noonday, when there are no clouds, the light is white. Our little domestic sun (the electric lamp) is precisely of that kind. We cause the light from our little domestic sun to impinge upon our screen. I take for this purpose simply a little strip of light—a slice of light, if I may use the expression—and there that slice of light is thrown upon the screen and produces that white rectangle which you see. I will interpose in the path of the

light some coloured glasses. Here I have a green glass. Well, you see that now the light on the screen is green. Here I have a blue glass, and that causes the light to be blue; and here I have a red glass, and that causes it to be red. What I want you to understand is that the blue and the green and the red are all in that white light. And now I want to pull those distinct colours one from the other. I want to separate the colours which produce that white light. I do that by sending the light through a body of a certain shape, which is called a prism. We will cause the light to pass through it. [The experiment was performed, and the usual spectrum appeared on the screen.] Is not it lovely? I have seen it a great many times, but never without wonder at its beauty. But now I want to make that longer. I will send the light through another prism. Here it is. You will observe that by using this other prism I can manage to make my coloured image a great deal longer. This coloured image which I obtain by sending the light through the prisms is called the spectrum; and the great Sir Isaac Newton proved that the slice of white light that you saw a moment ago upon the screen has contained in it all that numerous mass of colours which appear in the spectrum. Now, I wish that I had a ruddy faced boy that I might cause him to pass through that spectrum. You would find his ruddiness varied very much in passing through the various colours. I want to bring before you the fact that the colour of a body is owing to the colour which it throws back to the eye. Take a rose. When the white light of the sun falls upon the rose, it enters the rose some depth, but, as it is ejected again from the rose, certain colours are quenched, and certain colours are sent back to the eye, and the colour of the rose is due to the colours sent back to the eye.

Why was the red glass red? Because it quenched the other colours, and allowed only the red to pass. And what is true of red glass is true of red cloth, or of any other colour. Now, I want to show you that these colours are thus quenched. Here I have a beautiful piece of red cloth. It is now vividly red in the red light of the spectrum. But why is this red cloth red? It is because it quenches the other colours, and sends the red colour back to the eye. If we pass it on to the green part of the spectrum it will send back no colour to the eye, and there it is black. Again, we will take the opposite experiment. Here is a piece of green silk. The green silk is green because it quenches all the other colours except green, and sends the green colour back

to the eye. When this green silk is placed in the green part of the spectrum it is, you see, a vivid green. Now I place it on the red part, and there it is simply black. Thus the colour of a body depends partly upon the colours quenched by the body, and partly upon the colours sent back to the eye.

Now, Mr. Cottrell has here a little apparatus—simply a cell—and his object in handing it to me is that I may show you the influence of depth in producing colour. Water is so feebly coloured that, in order to make its colour evident to you, I have been obliged to have that long tube. You see the colour sometimes on the glaciers of Switzerland, in beautiful blue pools of water. Perhaps very many of the boys present will, when they grow older, visit the coast of Naples. Very likely they will go to the end of the Island of Capri, and there they will find coming down the steep precipitous coast, at a certain place, a little arch, just large enough to admit a boat. You pass underneath this arch, and you find yourself under a huge grotto, the walls of which shimmer, in magic beauty, with the most delicate azure light. The reason is that, in consequence of the smallness of the passage, the light is unable to get into the grotto by the entrance, but it first plunges into the blue sea, and then comes up again and illuminates the cavern, so that it has to pass through twice the depth of the water before it reaches the grotto, and, in consequence of the depth of water through which it has to pass, it gets coloured blue. When I say that the light is coloured blue, I mean that its red and yellow and orange and all the other rays except the blue are cut off by the water, and only the blue remains. Now, the experiment I am going to show you is simply to illustrate the influence of depth. Here is a cell composed of a thin chamber; here is one somewhat thicker; and here is one thicker still. The spectrum is on the screen, and if I simply interpose this thin cell, containing a light blue liquid, in the path of the beam you see that it has very little effect indeed upon the spectrum; and the reason is that the stratum is so thin that it cannot rob the light of its rays. Now, I will pour more of this blue liquid into the thicker cell. You observe now that by thickening the layer I have cut away the red ray altogether. You see how little light remains if I make the layer still thicker; and if I went on in this way I should actually cut away the whole spectrum with a substance which, when used in a thin layer, has hardly any effect at all upon the light. In a drinking-glass the water is not in a sufficient mass to give a colour to the light. But in the tanks at Canterbury it is a most delicate

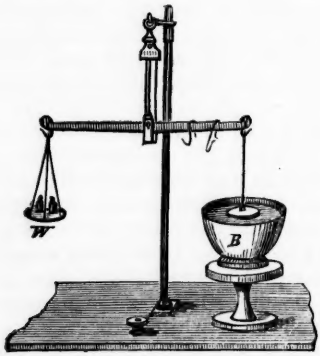
sky-blue. If you drop a pin into one of the tanks, which contain 120,000 gallons each, you can see the pin lying at the bottom. I have thrown farthings into the tanks over and over again, and they are scarcely dimmed by the depth of 16 ft. of this beautiful chalk water; and this water has many other things to recommend it. For instance, I have looked into the Report of the Registrar General for information with regard to the influence of temperature upon Thames water, and I have found that, in the early part of the month of June last year, the temperature of the Thames water rose from 60° to 67° or 68°, and that the death-rate from a certain complaint was at first represented by the number 23, but it rose up in three or four weeks to 349, and this increase the Registrar General attributes entirely to the rise in the temperature of the Thames water. Now, one great advantage of this Canterbury water that comes from the body of the chalk is that its temperature is perfectly constant. It is always at an agreeable temperature of 51° to 52°; and if it is properly laid and conducted to the houses it cannot possibly be the propagator of any form of infectious disease.

But now I pass on from the temperature of the Canterbury water to show you the colour of the water. I have filled this long tube to half its depth with the water, so that half the beam of light which passes through the tube will go through the air, and the other half will go through the water. [The 15 feet tube, to which a reference had been made in an earlier part of the lecture, was used in this experiment. The beam of light, after passing through the tube, was received on a white screen. A light green tint was communicated by the water.] There we have a great deal of colour due to the purest water that we can find.

Now I want to point out to you another physical property of water. The liquid state of matter such as water represents is sometimes defined to be that state in which cohesion is absent,—a state in which the particles do not cohere, and in which they are perfectly mobile and are not held together by any force. I would ask you to remember that that is an erroneous definition of the liquid condition. The liquid condition is this:—The little particles of water (and I shall tell you in a future lecture what these particles are called, but for the time being we shall call them "particles") are gifted with the power of sliding over each other; but, while gifted with that power, they can exercise a very great resistance to being torn asunder. We may measure the cohesion of water by a simple apparatus. Here is a plate of glass,

and we can easily balance that plate of glass by a weight (w), and then bring the glass down upon a sheet of water (Fig. 3); then, by adding more weights upon the scale-pan, we can determine the weight necessary to sever one part of the water from the other. Take the case of a soap-bubble. If I had time I could show you the beautiful zones of colour which a soap-bubble produces; and, by means of the zones of colour, we can approximately determine the thickness of the bubble. You sometimes see a heavy drop of water pendant from a soap-bubble; and if you reflect upon this you will see that the film of the bubble must have a tremendous amount of tenacity in order to support the drop of water which hangs from it. Prof. Henry, of Washington, estimated the tenacity of water at several hundred pounds per

Fig. 3.



square inch. But you will say, perhaps, that the soap confers this tenacity upon the water of the bubble. Well, Prof. Henry says that it is not so, and that water, if properly dealt with, is really more tenacious than water with soap in it. But, however true that may be, I want, at all events, to show you that we can get beautiful bubbles and beautiful films of water without any soap whatever.

Here is a tube connected with a cistern at the top of the house, and I am going to make an experiment with it upon a grand scale. It is an experiment which was made by an eminent French investigator, M. Felix Savart. Savart produced films of water by allowing jets of water to fall upon small surfaces. It is wonderful what care we must take in this experiment. The slightest agitation would destroy the

beautiful films which it is our object to produce. I will turn the water on and allow it to fall, or to impinge, as we call it, upon this little brass plate. [A stream of water from the end of a lead pipe was allowed to fall on the centre of a circular flat brass plate, which was supported by a brass pillar standing in the centre of a large concave metallic pan. The water, upon reaching the brass plate, was spread out in all directions, and fell as a continuous film, the shape of which was, for the most part, dome-like, but occasionally became nearly globular.] Now you have that beautiful umbrella—that beautiful parasol of water. You observe the tenacious way in which the water clasps the stem. [The experiment was repeated with two plates of larger sizes. The falling water was illuminated by a beam of electric light, the beautiful effect of which was varied by the light being caused to pass through coloured glasses.] I see that there are small bubbles of air coming down with the jet of water, and that is the cause of the film breaking so soon; but still it is very beautiful. I do not want you to underrate it at all. Well, this illustrates the tenacity of water where there is no soap mixed with it in order to give it tenacity.

We shall defer the consideration of the other physical properties of water to our next lecture.

ANALYSES OF BOOKS.

How to Work with the Microscope. By LIONEL S. BEALE, F.R.S., President of the Royal Microscopical Society. Fifth Edition. 518 pp. London: Harrison, Pall Mall. Philadelphia: Lindsay and Blakeston.

THE reader of this comprehensive treatise on all that relates to practical research by means of the microscope will hardly recognise, in the present magnificent volume, the little book of 124 pages, bearing the same title, published in 1857. "How to Work" most fitly explains the character of the book, every page being eminently practical; that preceding the title-page contains a note to the reader, in which the author says—"This work may be read by carefully studying the figures, and then referring to the text. A description of every drawing is placed beneath it, and a reference is given to the page upon which the subject of the drawing is considered."

The illustrations form a very important part of the book, occupying no less than 98 pages, exclusive of cuts inserted in the text. The figures of tissues, especially those very highly magnified, are marvels of delicate wood engraving,—a mode of reproducing drawings greatly in favour with the author, and exclusively employed throughout the work. By a very simple and ingenious process some of them are printed in three colours, with good effect. Three electro-copies of the wood block are taken; from one every portion is cut away except the *bio-plasts*, coloured red by the alkaline carmine stain; on the second, the *capillaries* injected with blue are left, and the remaining block is arranged to give the outline and shading in black. The combination of the three blocks presents an accurate view of tissues finely injected and stained.

The seven parts into which the book is divided comprise:—

1. The Microscope and all necessary apparatus, with the mode of using the various appliances. Ten pages are devoted to the manner of making drawings with the microscope, and the means of multiplying them by engraving and lithography.

2. On examining, preparing, and preserving objects, including dissection, cutting thin sections, injecting, and the use of various staining materials. This important part occupies 53 pages, and is so arranged that beginners can readily find the portions useful to them without being troubled by the very detailed account of processes more fitted for the advanced student. Respecting the use of dyes, the author is especially careful to distinguish between stains used for colouring *bioplasm*, or living

matter, and those employed for demonstrating the structure of formed material; the dyes differ widely both chemically and in the mode of their application.

3. The examination of various substances, both organic and inorganic, is in this part treated still more in detail. The processes used in the examination of rocks and fossils have been contributed by H. C. Sorby, F.R.S., and Frank Rutley, of the Geological Survey. Mr. Sorby's remarks on the use of the Polariscope are worth quoting at length, as the value of this appendage to the microscope is still far from being generally understood. Mr. Sorby writes:—"Polarised light must not be used simply to show structure, or, as is too often the case, merely to show pretty colours, for it is a most searching means of learning the nature and molecular constitutions of the substances under examination. The action of crystals on polarised light, as applied to the microscope, is due to their double refraction, which depolarises the polarised beam, and gives rise to colours by interference, if the crystal be not too thick in proportion to the intensity of the power of double refraction in the line of vision. This varies much, according to the position in which the crystal is cut, and therefore, in a section of a rock, different crystals of the same mineral may give very different results; but still we may often form a good general opinion on the intensity, and may thus distinguish different minerals whose intensity of action varies considerably. But besides this, the intensity, but not the character, of the depolarised light, varies according to the position of the crystal in relation to the plane of polarisation of the light. There are two axes at right angles to each other, and when either of them is parallel to the plane of polarisation the crystal has no depolarising action, and if the polarising and analysing prism are crossed the field looks black. On rotating either the crystal or the plane of polarisation the intensity of depolarising action gradually increases, until the axes are inclined to 45°, and then gradually diminishes till the other axis is in the plane of polarisation. If, therefore, we are examining any transparent body, and find that this takes place uniformly over the whole, we know that the whole has one simple crystalline structure; whereas if it appears as it were to break up into detached parts, each of which changes independently, we know that it is made up of a number of separate crystalline portions, either related as twins or quite independent of each other, as other facts may indicate. By using a plate of selenite of suitable thickness, we may also ascertain in what directions the crystal raises and depresses the tint of colour given by the selenite, and can thus determine the position of the principal axis of the crystal."

4. Treats of Chemical Analysis applied to microscopical investigations. The portion devoted to Spectrum Analysis is from the pen of H. C. Sorby, F.R.S., and scarcely needs comment. A list of works on the subject is appended.

5. Is entirely devoted to Photography. The author has here been assisted by Dr. Maddox and Dr. Clifford Mercer. The instructions given are of the fullest kind, and include some of the most recent improvements.

6. Is particularly Dr. Beale's own, and treats upon original research, especially with the extremely high powers which, combined with the author's manipulative skill, have contributed so much to the determination of the minute details of nerve structure. The special mode of conducting the operations is given at great length, and the interpretation of the appearances presented fully discussed: here the whole resources of the microscope, aided by chemistry, are brought into play, and the author's deductions from his observations concerning structure, formation, growth of tissues, and vitality carefully considered. It is in this portion of the book that the particularly beautiful illustrations before mentioned abound.

7. On the construction of Object Glasses, which appears for the first time in the present edition, explains much that has hitherto been a mystery to microscopists. Little respecting these marvellous optical combinations has till now passed beyond the limits of the workshop; but Mr. F. H. Wenham, F.R.M.S., has kindly placed his published papers and the results of his experience at Dr. Beale's disposal, and given most valuable information as to the manner of working lenses and prisms, with suitable formulæ for their construction. Mr. James Swift has also furnished some manipulative details.

The work concludes with tables for practising the use of the microscope, commencing with very simple operations, and gradually advancing to those of considerable difficulty: the whole are referred to the pages of the book where the description may be found, and also to the plates. This is followed by a list of works and papers on the microscope and matters relating to it, and an Appendix containing an account of apparatus which has appeared during the progress of the work.

Annals of Chemical Medicine, including the Application of Chemistry to Physiology, Pathology, &c. Vol. I. Edited by J. L. W. Thudichum, M.D. London: Longmans. 1879.

This is the first volume of a new scientific periodical which proposes to treat entirely of Chemistry applied to Medicine, and will contain papers on original researches to be carried out in physiological, chemical, and pharmaceutical laboratories in Great Britain and elsewhere. The oftentimes astounding ignorance shown by medical men on chemical subjects is frequently excused on the ground that the latest researches in Chemical

Medicine are scattered abroad in various periodicals and transactions published in different languages and localities. The present issue is intended to render this excuse null and void for the future. The present volume consists of some twenty-three articles, most of them being full or summarised papers read by Dr. Thudichum before the Pathological Institute. One of the most interesting of these is the biography of the great German physicist, R. J. Mayer. No. XX. is also an interesting paper on the colouring-matters of bile, which appears to clear up satisfactorily much of the confusion that has hitherto reigned amongst these interesting bodies. There are two excellent name and subject indexes.

We cannot agree, however, with Dr. Thudichum in advocating the introduction of such words as "to fell," "hydrochlor," "hydrothion," and "molecle," for to precipitate, hydrochloric acid, hydrosulphuric acid, and molecule.

Mind in the Lower Animals in Health and Disease. By W. Lauder Lindsay, M.D., F.R.S.E., F.L.S. London: C. Kegan Paul.

We have here two goodly volumes on a subject which, though hitherto much neglected, must be pronounced to be of the deepest interest. It will yet be seen that the attempt to constitute a science of mind from the exclusive study of the human species is no less a mistake than that of the old naturalists who began with a description of our bodily structure, and then worked down to the lower organisms, thus going from the complex to the simple.

The author tells us that he has studied the subject of mind in other animals, as compared with that of man, for a series of years, and that his point of view is that of a "physician-naturalist." His professional speciality being the treatment of mental alienation in man, he passed to the study of comparative pathology, the result of his inquiries being that the lower animals are subject to the same diseases as we are. Turning to psycho-pathology, he extended this conclusion to mental disorders, and was thus finally led to an "investigation of the normal phenomena of mind throughout the animal kingdom." Whether this way of entering upon the latter subject is the happiest is perhaps open to doubt. He aims at indicating, first, the spirit and direction in which such an inquiry ought to be prosecuted; secondly, its claims on our attention; thirdly, the desirability of exactly separating the known from the unknown; fourthly, "the new significance of certain facts as interpreted

by the light of modern science;" and lastly, "that facts which controvert popular fallacies are nevertheless facts."

The question of the existence in the lower animals of an immortal soul has been purposely avoided, as not admitting of scientific demonstration. In the first volume the author, after some introductory chapters,—in which we find much to agree with, and also much that is doubtful, and, in our opinion, altogether beside the question,—treats of the dawn of mind in man, the mental condition of children and savages, the evolution of mind in the ascending zoological scale, the alleged intellectual and moral supremacy of man, the inter-relations of instinct and reason, and of unsolved problems in the psychology of the lower animals. He thence passes to morality and religion, to education and its results, to adaptiveness and fallibility, seeking everywhere to demonstrate that the mental phenomena observed in man and in animals are substantially one and the same in kind.

In the second volume he deals with the defects and disorders of mind in man, and in the lower animals.

Finally, he draws certain practical conclusions as to the curability and treatment of animal insanity. An appendix gives the bibliography of the subject, and the scientific names of the animals mentioned in the work.

In so far as Dr. Lindsay is attacking the prejudice of an utter difference of kind between man and the rest of the animal creation, no reader of the "Journal of Science" can doubt that we are with him heart and soul. But we have to ask in how far has he made out his case, and whether he has succeeded in silencing opponents? Here we must admit that we experience no little disappointment. We fear that he has not been sufficiently critical in the selection of authorities. Not to speak of certain literary characters whose training has been anything but scientific, and whom we may well imagine to be occasionally carried away by their feelings, we find occasional references to a certain "Lawson." As he is mentioned in connection with New Guinea, we fear the author must mean Captain Lawson, who invested that island with a fauna totally different from what other travellers have there observed, and who ascended a mountain more than 30,000 feet high in less time than it takes to ascend Etna. We should as soon think of quoting as an authority Lemuel Gulliver.

The anecdote, taken from the "Animal World," that some old rats, finding a young one drowned, "wiped the tears from their eyes with their fore-paws," requires to be taken with a very large grain of salt. The observer must have stood very near to be sure that they were weeping. We have also Watson's story of the blind rat led by a companion by means of a stick, a narrative fraught with internal improbabilities and certain to break down under cross-examination. It must not be forgotten that in

several capital cases the author thinks that further observation and experiment is needful, and in his bibliography he calls in question the accuracy of some of his authorities. But would it not have been better to have brought forward none but unimpeachable evidence?

Just as many readers will conclude that Dr. Lindsay has said more than can be proved in favour of animals, there are others who will contend that he has exaggerated the defects and shortcomings of man. The story of the fight between a man and a bull dog, said to have occurred at Hanley, is scarcely so well-founded as to call for admission in a scientific treatise. As regards the degraded state—moral and intellectual—of certain savages, it is also painted with too gloomy colours.

Sometimes the author seems to have mis-read his authorities. Thus he quotes Belt as speaking of the production of artificial insanity in a white-faced monkey by means of corrosive sublimate. As we remember the passage the animals thus maddened were not monkeys but ants, and so, indeed, Dr. Lindsay quotes this incident in another part of his work.

Perhaps, however, the greatest defect in an otherwise valuable work is the frequent repetition of facts and arguments which have been previously given. Thus pp. 166, 167, 168, and 169 seem mainly a repetition, at somewhat greater length, of matter to be found on pp. 41, 42, and 43. On p. 404, and again on p. 416, we read that a "big dog, after rescuing a little one from drowning, cuffed it first with one paw and then with the other."

A lamentation over the fact that in Glasgow, on account of three deaths from hydrophobia, the authorities—in our opinion most wisely and justly—ordered the destruction of all stray dogs, occurs in vol. i., p. 90, and vol. ii., p. 363, in the latter case being accompanied by some comments which sadly shake our confidence in Dr. Lindsay as a reasoner. Indeed the glorification of dogs and the plea for immunity for their offences is but too prominent. Thus the destruction of dogs for "*mere* biting" (*sic!*) is pronounced "injudicious butchery." How very few dogs in a country like Britain, and especially in towns, are anything but a nuisance, the author does not seem to have asked.

A chapter on animal stupidity—in which the intellectual character of the ass, the goose, and the pig is fully vindicated from the charges commonly brought against them—is introduced among the abnormal manifestations of mind. Why should attributes common to an entire species be considered other than normal?

The author's repudiation of the phrase "dumb animals," and of the rash assumption that language constitutes a boundary line between man and beast, merits the warmest approval. But it may well be asked why the fact that in the north of Scotland shepherds' dogs accompany their masters to church should be

adduced in proof of the religious feelings of animals, or why the rejection of a *Heliconia* by Belt's pet monkey, or of a gaily-coloured frog by ducks, should be cited as instances of individuality of taste and temper. Whilst fully recognising that animals of one species differ among themselves intellectually and morally, even as do men, we cannot see that such facts have the least bearing upon the question.

But we cannot enter further either into the defects or the merits of this work, and we will merely express the hope that it may contribute to weaken the stale prejudice of an antithetical distinction between man and the rest of the animal world.

On the Structure and Affinities of the "Tabulate Corals," of the Palæozoic Period, with Critical Descriptions of Illustrated Species. By H. Alleyne Nicholson, M.D. Edinburgh and London: W. Blackwood and Sons.

To the generality of readers, even including such naturalists as have never turned their attention to a close and exhaustive study of corals, this volume will be utterly void of interest. To the zoo-phytologist, on the other hand, it will be welcome as conveying the results of careful and accurate research, the more valuable, perhaps, from its special and unobtrusive character. The author is led to agree with Verrill and Lindström on the necessity of abolishing the *Tabulata* as a distinct and separate division of the *Zoantharia*. Under the old name of *Tabulata* he finds included at least twelve distinct groups—some of them *Hydrozoa*, others true *Zoantharia*, others again *Alcyonaria*, and a few forms quite uncertain in their affinities.

The work cannot but increase Prof. Nicholson's high reputation as an able and persevering worker in biological science. The illustrations included in the text are numerous, and, as well as the plates subjoined at the end, are very well executed.